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RAILWAY SHOPS.

BY R. H. SOULE.

V.

THE BOILER SHOP AND THE SMITH SHOP.

As in the case of the machine shop, the boiler shop does not admit of classification into a few types; a great variety of cross sections may be used, and many combinations of length and width; the requisites are floor space in proper proportion to the number of locomotives to be handled, proper provision of crane facilities, and sufficient tool equipment. Before the introduction of the overhead traveling crane boilers were moved between erecting shop and boiler shop on trucks by transfer table, and tracks extending into the boiler shop were a necessity; under present conditions no boiler shop need have more than a single track extending into it. In general, the boiler shop floor should be of wood, but about flange fires and forges should preferably be of earth, as a wood floor in those places will burn out very rapidly.

In any locomotive shop it would be an advantage to have the erecting shop and the boiler shop so located and related that they could have joint crane service; this cannot always be accomplished, however, and it is believed that there is not a single locomotive construction shop so arranged. Among locomotive repair shops several cases are found, for instance: Roanoke, Va. (N. & W.); Concord, N. H. (B. & M.); Dubois, Pa. (B. R. & P.); Elizabethport, N. J. (C. R. R. of N. J.); Reading, Pa. (P. & R.); Topeka, Kans. (A., T. & S. F.), and Montreal, Can. (C. P.). Although joint crane service between erecting and boiler shops is believed to be very desirable and economical, it is only fair to mention some other very successful shops where the two departments are separate and independent, for instance: Burlington, Ia. (C., B. & Q.); Chicago, Ill. (C. & N. W.); St. Paul, Minn. (C., St. P., M. & O.); Omaha, Neb. (U. P.); Burnside, Ill. (I. C.); Collinwood, O. (L. S.); Depew, N. Y. (N. Y. C.); McKees Rocks, Pa. (P. & L. E.), and Altoona, Pa. (P. R. R.). Compromise arrangements may be found at Jackson, Mich. (M. C.), and Columbus, O. (Pa. Lines); at both places the erecting shop cranes cover a portion of the boiler shop only.

In most locomotive repair plants one building serves for both boiler shop and tank shop, but separate tank shops are found at Chicago, Ill. (C. & N. W.); Altoona, Pa. (P. R. R.), and Baltimore, Md. (B. & O.); those at Altoona and Baltimore are longitudinal, while that at Chicago is transverse; in some respects a transverse shop is more convenient for tank repairs, as tenders do not receive as uniform treatment as locomotives do, and in many cases do not require handling by cranes at all, so that it is an advantage to be able to let them stand on the track on which they were originally placed, which could not be done in a longitudinal shop; the penalty for the transverse tank shop is either a transfer table or a system of fan tail tracks for approach.

In a boiler shop traveling crane service may be provided to good advantage over a much larger proportion of the floor space than in the machine shop; this is due to the fact that both the work and the tools are so much heavier in the boiler shop, and that the tools practically all have individual motor drives. In a boiler and tank shop the traveling cranes will be needed for moving and turning boilers and tanks, but nearly every individual tool will have to be provided with its own individual crane or hoist, or swing crane and hoist combined, these local cranes being in general hand operated. If boiler plates are stored outside the building, it will pay to install a hand or power yard crane over them, even in moderate-sized plants.

The head room in the boiler shop is often influenced by structural considerations, as always, for instance, where the boiler shop is an extension of the erecting shop and having joint crane service with it; but where there are no such limitations it may be assumed that the figures may be as in Table 9,

TABLE 9—HEADROOM FOR BOILER SHOPS.

Particular.	From floor to top of rail. ft. ins.	From floor to lower chord of roof truss. ft. ins.
Where heavy traveling cranes (say 35 tons) are used	28 0	35 0
Where light traveling cranes (say 5 tons) are used	19 0	24 0
In wings where many swing cranes are used	.....	22 0
In wings without cranes	.....	20 0

the conditions being normal and the width of crane bays moderate; the exact vertical distance between top of crane runway rail and lower chord of roof truss should be fixed only after the exact type and make of crane for each particular location has been chosen.

The capacities of boiler shop cranes under present conditions may be assumed to be as in Table 10.

TABLE 10—CAPACITIES OF BOILER-SHOP CRANES.

For what purpose used.	Capacity.
General floor crane	35 tons.
Riveting tower	25 "
Side bays	5 "
Local cranes over tools, from 1 up to	2 "

A list of tools for the boiler shop can be made up only for each concrete case; the very first thing to be known is whether a riveting and flanging plant is to be included, and in many cases this will be a question of grave doubt. In this connection it is interesting to note the introduction of several such plants in railway locomotive repair plants during the last few years; this may be due to the present period of activity, which results in extremely high prices and slow deliveries when flanged and riveted parts are ordered from the locomotive builders. Sometimes a compromise is made, the flanging being done by hand, and a riveting plant suitable for firebox work only being provided; a 12-ft. stake riveter will then answer, which also requires less head room than the usual 17-ft. stake machine for boiler work. The horizontal dimensions of the riveting tower are largely influenced by structural considerations, but an analysis of several examples shows that a rectangle 20 ft. x 20 ft. would be a minimum for a single machine, while a tower for two machines (placed on opposite sides of shop) in one case is about 25 ft. x 70 ft. If the riveting machine is set on the floor the height of tower from floor to lower chord of roof truss should be, for a 12-ft. stake machine, from 55 ft. to 60 ft., and for a 17-ft. stake machine, from 65 ft. to 70 ft. (Reading is 76 ft., which seems to be excessive.) At Altoona (Juniata shop) the 17-ft. stake machine is set in a pit, to reduce height of tower and bring the machine ram down to a level where the work can be handled from the floor.

The floor area in use for boiler and tank shops (considered collectively) ranges from a minimum of 500 sq. ft. per erecting shop stall, in small repair shops, up to a maximum of 4,000 sq. ft. in construction shops. The floor area of the new boiler and tank shops at the Schenectady works of the American Locomotive Company totalize above 10,000 sq. ft. per stall of the present erecting shop, but these new departments are probably proportioned to correspond to a new erecting shop of increased output. Railway repair shops of good size run from 1,500 sq. ft. to 2,500 sq. ft. per erecting shop stall, according to the variety of work they do, the lower limit being sufficient if fireboxes are made elsewhere, and the upper limit if a few new engines are built while repairs are being carried on.

THE SMITH SHOP.

In the case of the smith shop department of a general railway repair shop it is more difficult to establish proportions, particularly floor space, because it cannot be referred to any unit; the boiler shop is engaged almost exclusively on locomotive work, whereas the smith shop is used jointly on work for locomotives, passenger equipment cars, and freight equipment cars, and probably on both repair and construction work in one or another of these. Work for the maintenance of way department is also frequently handled in the smith shop. When all our principal American combination shops (that is, those

engaged on both locomotive and car work) are listed, it is found that smith shop floor areas range from 7,500 sq. ft. to 75,000 sq. ft., which limit is slightly exceeded at the new Montreal shops of the Canadian Pacific, where new work, both locomotives and cars, is to be undertaken on a large scale in addition to repair work. Most of our own combination plants, however, show a total smith shop floor area running from 20,000 sq. ft. to 40,000 sq. ft. The exact amount of smith shop floor space for any projected plant can be approximated only after consideration of all the facts bearing on the individual case.

If 20 ft. is adopted as the general head room (where traveling cranes are not used) of one-story structures, there is good reason for increasing it to 22 ft. where swing cranes are in general use, as in the smith shop. At the new Collinwood shop of the Lake Shore the smith shop head room is 24 ft. As swing cranes impose horizontal loads on roof trusses, and as these loads may be in any direction, or all in one direction, it is good practice to proportion the trusses accordingly, and to introduce a good system of horizontal bracing. The new Reading shop of the Philadelphia & Reading has a smith shop which is equipped with a traveling crane covering the entire floor space; this is a decided novelty; there are of course swing cranes as well, supported from the walls. An earth floor is the only practicable one for a smith shop.

The tools list will require great care; hammers from 6,000 lbs. down are used; forges, usually in three sizes, light, medium and heavy; furnaces in assorted sizes from the large scrapping furnace to the bolt and spring furnaces. Trade catalogues will make the way easy for selecting hammers and forges, but there is no authoritative source of information in reference to furnaces, which must be designed in imitation of the best practice which can be located and observed. The ideal fuel for furnaces is gas, which is in common use in steel works, but practically unknown in railway practice except for the single example at the Altoona (Juniata) shop of the Pennsylvania Railroad, where a battery of gas producers supplies all the smith shop furnaces, and one in the boiler shop. The use of oil as a fuel, which is quite common in bolt and spring furnaces in railway shops, is a cheap and acceptable substitute for gas, but is hardly applicable to very large furnaces. Where a great deal of scrap is worked into slabs, enough to keep one hammer occupied, it will pay to have two furnaces to feed it, otherwise the work will be interrupted whenever the furnace requires re-lining or patching, which happens quite frequently.

An examination of the lay-out plans of a considerable number of smith shops discloses the fact that there seems to be no preferred method of grouping small forges for hand work, but the indications are that such forges should be spaced not less than 15 ft. center to center (preferably more), should be ranged along the side of the shop, and stood at an angle to the side wall; this makes the wall available for tool racks, and leaves the finished work lying on the ground adjacent to the gangway, from which it can be gathered up without interfering with the smiths and helpers. Medium and large forges are usually equipped with swing cranes, and can be used to best advantage when located away from walls. The modern smith shop should have both a pressure fan for blast and an exhaust fan to clear away smoke; the down draft system of exhaust has been much used of late, but is susceptible of improvement.

Bolt headers, bulldozers and forging machines are items in the essential equipment of the railway smith shop. These and steam hammers require the use of dies and formers, some of them very heavy; provision should be made for storing them outside the shop, and a hand traveling crane is very useful in this connection.

The general scrap yard should be located near the smith shop, in order that as much wrought-iron scrap may be redeemed as possible. With electric driving available a shear may be located in the scrap yard, and at a few shops a small train of rolls (with heating furnaces) is provided, in order that rods may be rerolled to smaller sizes.

(To be continued.)

STEEL-FRAME, SIDE-DOOR, SUBURBAN PASSENGER CARS.

ILLINOIS CENTRAL RAILROAD.

The most interesting and important development of recent years in passenger transportation equipment is now nearly ready for practical application on the Illinois Central at the Chicago terminal. Eight suburban cars are being built upon a new plan which has been worked out most carefully and completely by Mr. A. W. Sullivan, assistant second vice-president, and Mr. Wm. Renshaw, superintendent of machinery, of this road. The basis of construction is the use of side doors. This necessitated steel under and upper frames and involved a large number of new and difficult problems, all of which appear to have been solved in an admirable manner. When the cars are completed they will be fully illustrated in this journal. We are now permitted to present the theory underlying this development, which we believe to be one of great importance.

At the time of the Chicago World's Fair this road learned the value of the side-door principle in handling 19,000,000 passengers in the most satisfactory service of the kind ever attempted. With the crude side-door equipment in temporary use at that time it was found possible to load 1,000 passengers in 10 seconds and unload them in the same amount of time, without the pushing and crowding incident to such movements in cars of the end-door type, and in contrast with the violent struggles and personal injuries which occur during rush hours on the New York and Brooklyn elevated railroads.

So successful was this method in facilitating train movements that upon one occasion five trains, each carrying 1,000 passengers, were loaded and discharged successively from one platform in four minutes, and this rate of movement could have been maintained longer had not the rush subsided. As it was, the total number of passengers transported on the day of maximum traffic was 509,000, without mishap of any kind.

The concentration of crowds of passengers at the ends of cars is wrong as a transportation principle. It is manifest that a plurality of side doors causes a diffusion of movement, decreases congestion and accelerates progress. If the mean distance traveled is one-half the width instead of one-half the length of a car, the movement will be quicker, aside from the crowding. With side doors ordinary stops may be reduced to from 3 to 5 seconds and a car may be entirely emptied or filled in 10 seconds. Ten passengers will use each door, and this number is independent of the length of the car. A long car may therefore be unloaded as quickly as a short one, and long cars increase the capacity of a train. For unloading 60 passengers from a car having two end doors, 30 seconds are required as compared with 10 seconds for a side door car. If the cars hold 120 passengers this means two passengers per second in one case and 12 in the other, under normal conditions. Doors placed in one side of a car will not cause a troublesome draft in cold weather.

With a side aisle and transverse seats, passengers may enter any door and find seats after the train has started, thus avoiding the delays incident to searching for a seat from door to door, thus equalizing the distribution as in cars with end doors. In this respect this construction is an improvement over foreign practice and also that used at the time of the World's Fair.

With the high acceleration of modern electric service and frequent stops as in large cities, the frequency of train movement will depend for its ultimate development upon the time consumed in station stops rather than that in the movement between stations. The type of cars and character of movements of passengers to and from them will play an important part in the development of the future. Now that the difficulties of construction have been solved the car with side doors seems likely to replace that with end doors.

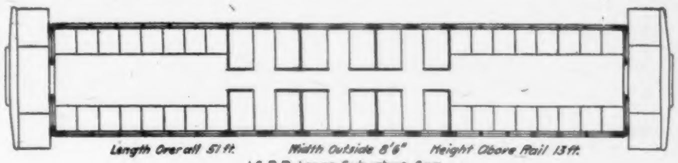
The accompanying diagrams show only seating plans and are not intended to represent the actual construction. The

diagrams represent a car 65 ft. long and 10 ft. 6 ins. wide which will employ steel framing.

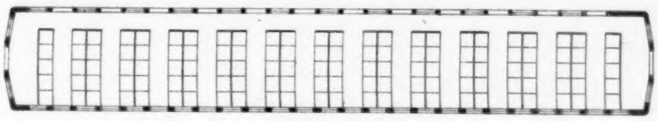
Plan No. 1 is intended for a road with terminal loops, and platforms on the outside of the track, although it may be used without the terminal loops by having the platforms on the same side* (east or west) of each track. Plan No. 2 serves the same purpose as plan No. 1, with the further provision that passengers may enter and leave the car on both sides. This plan is intended for use where the platforms are principally on one side, with an occasional island platform on the other side of the track. The capacity of this plan is the same as that of plan No. 1. Plan No. 3 is intended for use where there is considerable travel of moderate volume entering and leaving the car on both sides. The provision of having the aisle extend one-half length on each side, with cross aisle in the middle, is a desirable one where there is no great rush of travel, as it gives the seated passengers the same freedom from passing travel in and out of the car, as does plan No. 1. There is, however, a loss of a few seats by this arrangement, this plan for the small car seating four passengers less than plans Nos. 1 and 2. Plan No. 4, with aisles and doors the full length on both sides of the car, is designed to meet the requirements of the very heaviest travel, with frequent stops at

Upon the Illinois Central Railroad two sizes of suburban cars are at present in use—the small car, which is of the same dimensions as those of the elevated railroads, with seating capacity of 48 passengers; and what is known as the large suburban car, which is 51 ft. long, 8 ft. 6 ins. wide, with seating capacity of 56 passengers.

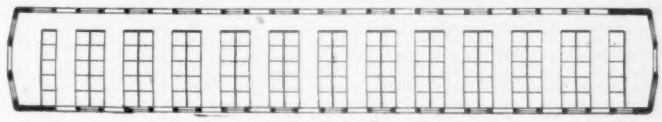
On the Illinois Central it is desirable to increase the size of cars so as to utilize all the space available between the platforms at stations, which has led to the adoption of the width of 10 ft. 6 ins.; and a length of 65 ft. is found to be a suitable one for that service. Some comparisons have been made showing the difference between the cars at present in use and the large improved car. The most noticeable difference is in the seating capacity, which is increased 114 per cent., with an increase of but 27 per cent. in the length of the car. The fol-



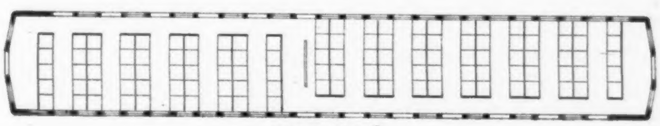
PRESENT SUBURBAN PASSENGER CAR.



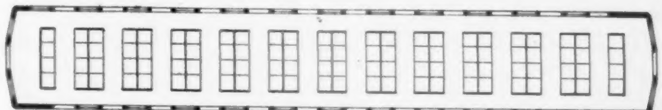
PLAN NO. 1.



PLAN NO. 2.

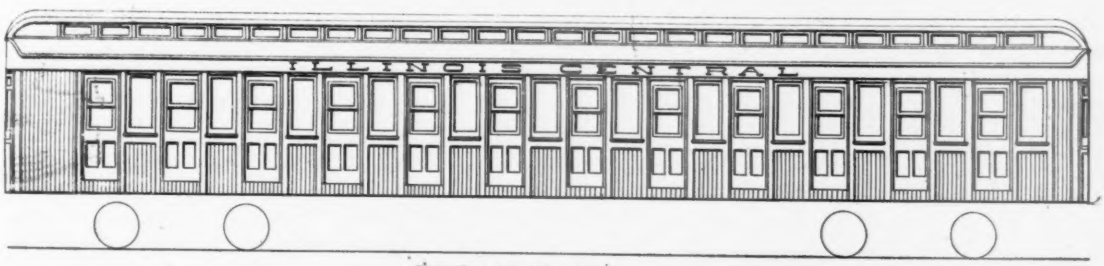


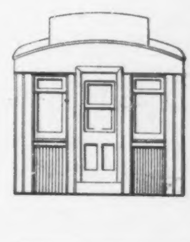
PLAN NO. 3



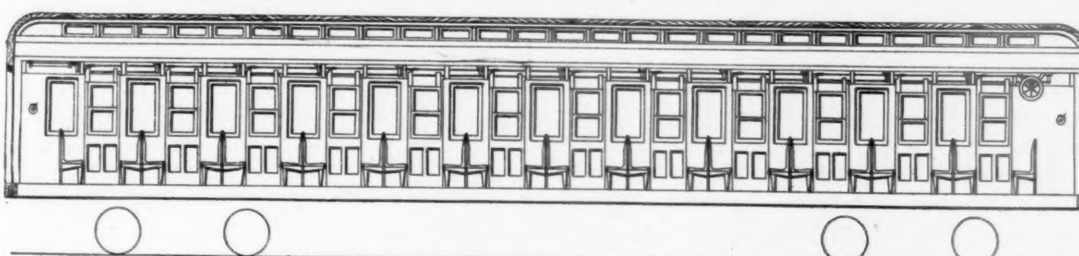
PLAN NO. 4.

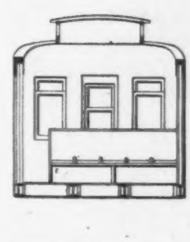
SEATING PLANS, SHOWING DIFFERENT ARRANGEMENTS.





Elevation–Door Side–Plan 1.





Longitudinal Section–Plan 1.

STEEL-FRAME, SIDE-DOOR SUBURBAN PASSENGER CARS.

BY A. W. SULLIVAN AND WILLIAM RENSHAW.

intermediate stations having platforms on both sides of the track.

The weight of the new car per passenger by this construction will be greatly reduced, combined with an increase in the strength of the car beyond that of anything heretofore attained in car construction, as will be seen from the following figures:

	Length.	Seating Capacity.	Weight.	Weight per Passenger.	Floor Strength. Safe Load per Square Foot.	Floor Strength. Ultimate Load per Square Ft.
Improved suburban car	65 ft.	120	78,000 lbs.	650 lbs.	160 lbs.	800 lbs.
Regular suburban car	51 ft.	56	38,000 lbs.	679 lbs.	76 lbs.	380 lbs.
Standard coach	61 ft.	62	86,000 lbs.	1,387 lbs.	81 lbs.	405 lbs.

lowing table shows the seating, standing and total capacity of the different plans compared with the cars now in use:

	Seating Capacity.	Standing Capacity. Clear of Entrance and Exit.	Standing Capacity. Full.	Total Capacity Seats, Standing and Clear.	Seats, Standing and Full.
Plan 1	120	48	60	168	180
Plan 2	120	48	60	168	180
Plan 3	115	53	65	168	180
Plan 4	96	72	96	168	192
I. C. suburban	56	0	41	56	97

In the matter of standing room there is great advantage to the passengers in that so large a number can stand clear of the entrances and exits. It is also an advantage to avoid having a large group of passengers standing together, particularly when dependent for support upon straps suspended from the roof of the car. The solid group of passengers which can gather in one mass in a car having a wide center aisle will be

less able to resist the lunging effect of high rates of acceleration and retardation than when they can individually brace themselves against a rigid support of medium height, and thus avoid discomfort, and frequently the distress that comes from the swaying of such a mass of passengers.

It is of more importance now than ever before that passenger cars should be constructed of the greatest strength, consistent with reasonable weight. To obtain this result, a metal frame work is necessary not only for the floor of the car, but for the walls and roof, in order that when collisions occur, especially at high rates of speed, or when derailments occur and cars rub against the walls of tunnels or other structures, the floor and sides of the car will not be demolished, as is quite likely to be the case with lightly constructed wooden cars.

The greatly increased capacity of the improved suburban car is not due altogether to its larger size, as the following comparative statement shows that per foot of length the new car has 46 per cent. greater carrying capacity than the old:

	Present	Improved Suburban.			
	Suburban.	Plan 1.	Plan 2.	Plan 3.	Plan 4.
Length of cars	51 ft.	65 ft.	65 ft.	65 ft.	65 ft.
Length of cars per cent	100	127	127	127	127
Passengers seated	56	120	120	115	96
Passengers seated, per cent	100	214	214	205	171
Passengers standing	41	60	60	65	96
Passengers standing, per cent	100	146	146	159	234
Passengers, total	97	180	180	180	192
Passengers, total, per cent	100	186	186	186	198
Passengers per foot, seated	1.10	1.85	1.85	1.77	1.48
Passengers per ft., seated p. c.	100	168	168	161	134
Passengers per foot, standing	0.80	0.92	0.92	1.00	1.48
Passengers per ft., stand., p. c.	100	115	115	125	185
Passengers per foot, total	1.90	2.77	2.77	2.77	2.95
Passengers per ft. total, p. c.	100	146	146	146	155

The most noticeable feature of the improved car is the side door, of which in a car 65 ft. long, 12 may be placed on each side for entrance and exit of passengers, in addition to end doors to permit of passing from one car to another. The side doors may be operated either by hand or by compressed air, the controlling mechanism being located within the walls of the car and out of sight. The mechanism provides for the positive opening, closing and locking of the doors by air or by hand. It also provides for closing the doors, locking and unlocking, but not opening them, leaving that to be done by the passengers, which during the season of cold weather would probably be the preferable way. The doors may be operated from either end of the car, and if necessary also from the middle. The quickness with which the doors may be manipulated and the absolute control of them by the trainmen will greatly reduce the time of the stops.

We consider that the door arrangement of these cars possesses especial merit in safeguarding the passengers from personal injury. There being no hand-holds on the outside of the car and no possible means of effecting an entrance when the doors have been closed, there is no temptation nor any opportunity for a belated passenger to get aboard after the train has started; neither is there any opportunity for a passenger to get off the train before it has come to a full stop, because all of the doors are closed by air pressure and can be released only by the trainmen, which will not be done until the train has stopped. All movements, therefore, of entrance and exit can be made only when the train is standing at the station platform, and one of the principal hazards of the service is thus eliminated.

As to the opening and closing of the doors; the walls of the car being hollow and the doors moving between them, there is no chance for a passenger to be caught and injured by them when opened; when closed, the movement, at first rapid, is graduated automatically by air cushions, so that the final closing movement is gentle and safe. Should any portion of a passenger's garment become caught by the door when closing, the elasticity of the air pressure against the door will admit of the garment being withdrawn without injury. Furthermore, the air cylinder for the operation of the doors being quite small, it has not sufficient power to cause injury by its pressure should a passenger inadvertently be caught in the doorway when the door is closing.

The transverse arrangement of seats, with side aisles and doors, made possible by the metal construction used, permits the car to be made of the greatest width for the distance between the tracks. Upon important terminals, where land values are high and traffic dense, there is need for the most complete utilization of available space, and when combined with the wide car of maximum seating capacity the quickest possible movement in loading and unloading passengers is effected by means of side doors, the conditions necessary to the development of the ultimate earning capacity of the property are attained so far as such conditions are dependent upon the vehicle of transportation. The introduction of this type of car is destined to mark a new era in the development of rapid passenger transportation.

NEW LOCOMOTIVE AND CAR SHOPS.

COLLINWOOD, OHIO.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

IX.

TESTS OF CUTTING SPEEDS, SHAPES OF TOOLS, HEAT TREATMENT,

In connection with the motor-driven machinery of these shops, a systematic study of machine-tool operation is being made, and at this point an account of tests of cutting speeds with high-speed tool steels is introduced in the series of articles. These tests were carried out by Mr. H. H. Vaughan, assistant superintendent of motive power.

The intention at first was to make a comparative test between various makes of steel, determine which of them gave the best results in service and ascertain what could be expected in regular work. Mr. Vaughan soon decided, however, that the first thing to do was to take one brand that showed good results and make sufficient experiments with that to determine what could be expected, and then endeavor to carry out the results in the shop, leaving the comparison between one steel and another until later. It is not so important to obtain the small percentage of increase of output that one good steel can give over another, as it is to obtain the greatly increased output that several of the new high-speed steels can give over the old water-hardening steels.

It will be noticed that the tests were all made with 1-10-in. feeds. The feed is one of the factors affecting the cutting speed in any tool and material, the cut being the other; to state at what speed a cut can be taken, it is necessary to also specify the feed and depth of cut. In the majority of locomotive work the cuts do not appear to vary sufficiently to affect the question very much, but the amount of feed is a different matter and is very important. By adopting a constant feed for all roughing work as far as possible, this variable, which is the most difficult to deal with, is eliminated.

This system is being introduced at the Collinwood shops with very satisfactory results, as the cutting problem at once becomes very simple and can be watched by practically noting the speed at which the work is running.

The machine used during all the experiments was a Pond 28-in. engine lathe, direct driven by a motor of 7½-h.p., which could be temporarily overloaded to about 12-h.p. All tools were ground in a Sellers universal grinder, permitting them to be ground accurately to any desired angles.

The series of experiments were made upon three classes of material—axle steel, wrought iron, and cast iron—to determine the proper cutting-speed, feed, and depth of cut to be used, as well as the best methods of treating the steel, and the correct angles for grinding. A lateral feed of 1-10 in. was at once adopted as being satisfactory for most classes of work. A coarser feed would be very severe upon the point of the tool, and many cases may arise requiring a finer feed, depending upon the character of the work.

The question of the most efficient depth of cut is one which cannot be definitely answered from the data at hand, because the power of the driving motor did not permit a cut to be taken which was at all near the capacity of the tool. By varying the cut through the range possible the indications were

that the life of the tool at a constant feed and cutting speed was independent of the depth of cut. This is reasonable, for although the work of removing the metal increases directly as the depth of cut, after the point of the tool is buried, the cutting edge provided to do this work is increased a like amount. The remaining points must be taken up separately.

MEDIUM STEEL.

On axle steel the preliminary tests of Styrian tool steel, run dry with the tool ground with 5-deg. end rake and 25-deg. side rake, showed a well defined limit of cutting speed at about 45 ft. per minute, beyond which it was impossible to go without very quickly ruining the tool. At 48-ft. per minute the tool lasted 12½ minutes with a 1-10-in. x 3-16-in. cut, being very hot all of the time, the chips coming off a deep blue. It seemed reasonable to suppose from the endurance of the tool while hot that if the heat generated by cutting could be absorbed and carried away before it had time to heat the tool, the life of the tool would be greatly prolonged, and the cutting speed might be increased.

A water jet applied above the work would not accomplish this result on account of the water not coming into contact with the tool at the cutting edge. So a ⅛-in. copper tube connected to an elevated cask was carried along the tool rest on the leading side, the end directed upward toward the point of the tool at an angle of 45 degs., and through this was forced a mixture of lard oil, resinous soap and water, at various heads up to 12 ft. The above mentioned location of the jet was found to have the greatest cooling effect upon the tool, and splashed the least water; the results obtained from this arrangement of the water jet leave no doubt as to the advantages to be derived from its use on steel work. Other conditions being the same, a tool which burnt in 15 minutes running dry will run with the water jet for an hour or more in good condition. It is necessary to use just enough water to carry away the heat.

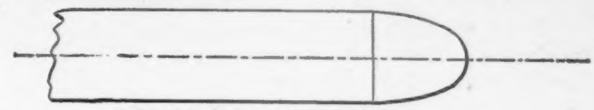
It is a rather remarkable fact, however, that the maximum safe cutting speed with a water jet is practically the same as without. The explanation is probably this: When tools have been removed from the lathe after cutting with the water jet, they have all been found more or less blue for a narrow strip along the cutting edge, showing that the water had not reached the extreme edge of the tool, even when applied under considerable pressure. At speeds up to 45 ft. per minute the body of the tool conducts the heat away from the edge rapidly enough to prevent overheating, but at higher speeds this action is not fast enough and the local temperature rises to a point which weakens the steel so that the side clearance is worn away, spoiling the tool.

A very thorough investigation was made of the proper angles at which to grind the tools. The results indicated that a tool with small side rake would last somewhat longer than one ground at a greater angle, on account of the stronger backing of the cutting edge, the difference being greater when running dry than with a water jet. But the action of the tools in removing metal is that of a continual shearing in a plane nearly perpendicular to the top face of the tool. For a given feed the area over which this shearing takes place is much greater for a flat-topped tool than for one with considerable side rake; hence, the power required to drive a flat tool is correspondingly greater.

This statement is verified by the fact that the chips from a flat-topped tool are blue and wear deep into the top of the tool, even with a water jet in use, while those from a thin-edged tool are not discolored and the tool is not worn, a great advantage in regrinding.

On a continuous cut, with the water jet, it was found entirely safe to use a side rake angle of 35 degs. to the horizontal, cutting 40 ft. per minute, but on an intermittent cut, the edge is likely to be nicked, causing overheating; so for average use an angle of 25 degs. is recommended. Using this sharp angle with the nose of the tool ground symmetrically brings the point very low. So it is recommended that the nose be ground at an angle of about 15 degs. to the shank, as shown in the accompanying sketch, which has the effect of raising the point, and makes a much easier running tool.

Tools hardened in oil showed an endurance nearly 100 per cent. greater than when hardened in the air blast. The best results are produced by heating a small portion of the end of



Tool with Symmetrically Ground Nose.

Nose Ground at angle of 15° A.E.

the tool to a bright red and cooling in oil. This makes a hard edge, but does not harden the body of the tool, leaving it tough, and making a tool adapted to heavy service. The only objection to oil hardening is that it sometimes cracks the tool, although seldom so seriously as to impair its strength.

WROUGHT IRON.

For the proper speed of cutting wrought iron no definite figures can be given, as this depends almost entirely upon the amount of slag in the iron. On good clear iron speeds of over 80 ft. per minute can be maintained easily, with a 1-10-in. feed and 3-16-in. cut, using a 25-deg. to 30-deg. tool and a water jet, but a piece of cinder is apt to ruin a tool at once, even when running as slow as 40 ft. per minute.

The indications are that a speed of 60 ft. per minute will generally be found satisfactory, using a water jet, with tools ground and hardened the same as for steel.

CAST IRON.

On cast iron, excellent results were obtained from tools hardened by being heated to a welding heat and cooled beside the fire. Such a tool will not hold a fine enough edge for finishing, but for roughing cuts on medium iron, it will far outwear an oil tempered tool. The side rake angle recommended for these tools is 15 degs. They may be run safely at from 45 to 55 ft. per minute, depending upon the density of the iron. If much scale is to be cut, 40 ft. is the highest safe speed. Light finishing cuts with oil hardened tools may be run as high as 85 ft. per minute, with a fair degree of accuracy.

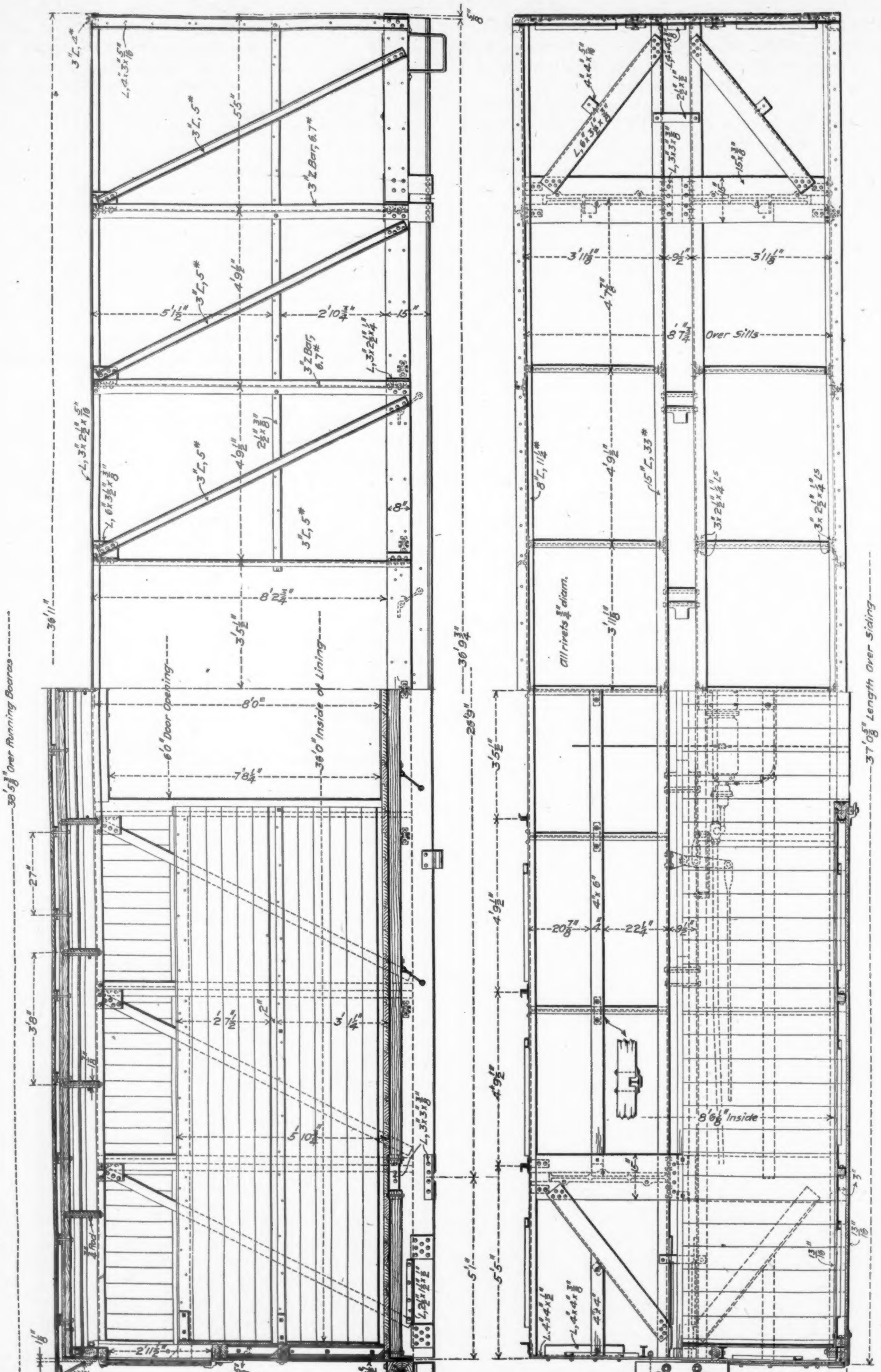
Cutting-off tools should be oil hardened and will last longer if the sharp corners are removed. They will stand a speed of 40 ft. per minute, but the cross feed allowable varies from .012-in. to .025-in., depending upon the hardness of the iron. If the feed is kept at the upper limit and the cutting speed is reduced, the tool will not last as long as with the high speed and finer feed.

Electrical measurements of power showed that a roughing tool working upon cast iron would absorb, without breaking down, only about 50 per cent. as much power as a tool of the same hardness cutting clean wrought iron, both being ground to suit the material worked upon. Coupled with the fact that a piece of slag in a wrought iron cut will ruin a tool with no increase in the power required, this indicates that the life of a cutting tool is dependent upon the character of the metal it is cutting as well as upon the power absorbed.

It is known that a tool applied with considerable pressure to a slow speed emery wheel will burn much sooner than if applied more lightly to the same wheel running faster. Working upon a material such as cast iron, whose action upon a tool is similar to that of an emery wheel, some benefit may result from the use of a high speed with a fine feed and consequent low pressure against the side of the tool. But in the case of wrought iron and steel, although no data on the subject are at hand, it is not probable that the increase of speed possible would compensate for the reduction in the feed.

Following is a tabulation of the principal results of the tests:

Material.	Form of Tool.	Angles. Side Rake.	End Rake.	Clearance.	Speed. Ft. Per Min.	Feed. Ins. Per Rev.
Axle steel.....	Roughing.	25°	10°	8°	35 to 45	.10
Wrought iron..	Roughing.	25°	10°	8°	35 to 80	.10
Cast iron......	Roughing.	15°	10°	8°	45 to 55	.10
Cast iron......	Cutting-off.	0°	0°	8°	40	.012 to .025



A STEEL-FRAME BOX CAR—BY C. A. SELEY.

STEEL FRAMES FOR CARS.

A STEEL FRAME BOX CAR.

BY C. A. SELEY.

MECHANICAL ENGINEER CHICAGO, ROCK ISLAND & PACIFIC RAILWAY.

In answer to an inquiry from the editor of the AMERICAN ENGINEER, "Has the time arrived when it is good business policy to discard wood in favor of steel for car underframes?" I wish to say from the mechanical and designer's standpoint, that steel has thoroughly demonstrated its usefulness, not only for underframes, but for side and end frames as well, and the only steel underframe car that I would advocate would be a flat car. The AMERICAN ENGINEER has kept the railway world well informed in regard to car designs and, among others, the composite cars built by the Norfolk & Western illustrate my argument.

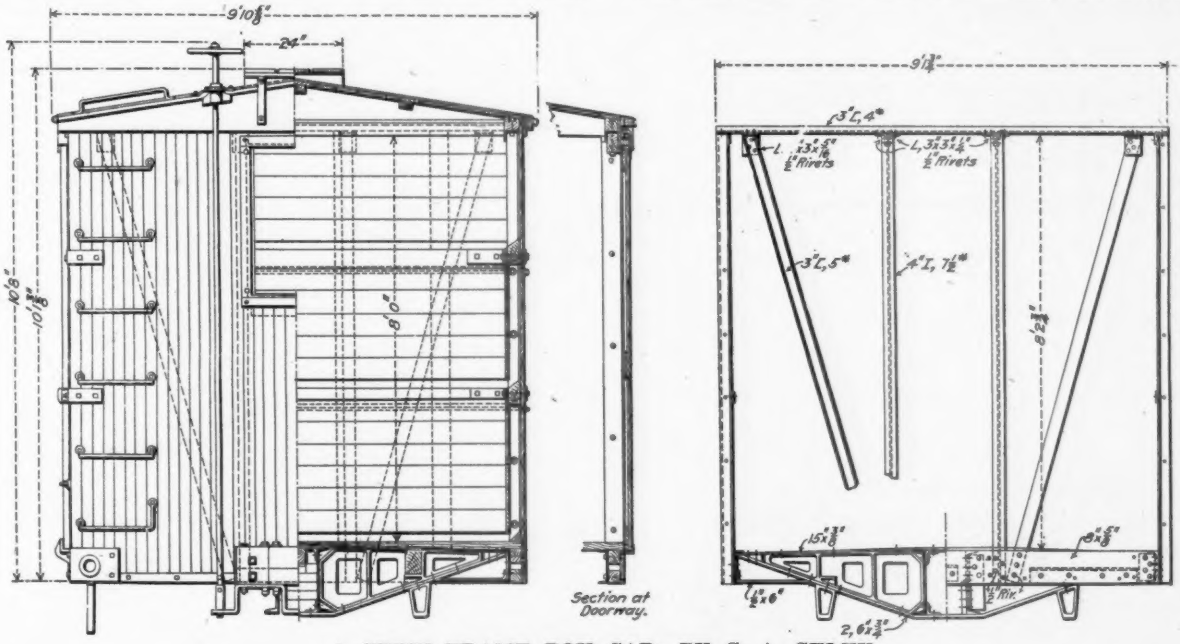
The frames of these cars, which are the carrying members, are of steel; the bodies, which serve merely to retain the load, are of wood, a material lighter and cheaper than steel, lasting its natural life, easily repaired and maintained. These cars are very staunch, of light weight, and consequently carry a high percentage of revenue load, besides having other advantages not necessary to take up at this time. These designs embrace gondola, hopper and box cars and their success proves the designer's contention that it is not necessary, in these cars at least, to provide the carrying strength in the underframing. The sides of gondolas and hoppers offer an opportunity for a truss, to be made of the side framing, that will carry any desired load without truss rods under the car. In the cars referred to the trussed sides carry nearly half of the load, the remainder being carried by center sills. It is not believed that the scheme of relieving the center sills of load and using light members for the pulling and buffing trusses only is the better one.

Box car designing offers a less inviting field for the use of steel as the side door opening interrupts the truss and it is not possible to put diagonals in the doorway to make it complete. Notwithstanding this, 100 box cars were built on the Norfolk & Western Railway in 1901 which have given excellent service. These cars have complete steel frames up to and including the side and end plates, and were illustrated in the AMERICAN ENGINEER in May, 1902. The only doubt the designer had in reference to these cars was in regard to the ability of the sides to resist bulging with a flowing load, as of grain. The posts and braces were mainly of 3-in. channels and it was believed that when stressed by a heavy load that the tension members would be aided thereby to resist deflection laterally and this supposition has been borne out by the performance of the cars, now nearly two years in service.

Some roads have reinforced their weak, wooden side framing by introducing steel channels or Z bars to resist lateral bulging under load. As these are not combined with the frame and are not under vertical stress they have only their own inherent lateral strength and are an expensive addition. The majority of box cars have comparatively weak ends and the amount of repairs on this account is very great, and has been much increased of late years, due to severe shocks in switching and the greater weight of modern cars. Some roads have used steel in the ends of box and stock cars with great advantage as a strengthener and no expedient in wood construction can equal the strength gained thereby.

The accompanying engravings illustrate a study in steel frame box car design for a car of the American Railway Association standard dimensions, viz., 36 ft. x 8 ft. 6 ins. x 8 ft. Some modifications of the Norfolk & Western design are here shown, which may or may not be of advantage.

The side posts are Z bars with an easy connection top and bottom, and being the tension members, they will resist very considerable lateral stress, their cross section being considerably in excess of the vertical requirements for strength. The flooring rests directly on the sills instead of on furring strips, and sufficient nailing strips are provided for center, intermediate and end nailing. Instead of sectional side girths a through girth of iron with wooden blocking is provided for the bottom girth, and the upper girths are as usually provided in wooden cars. An outside steel roof is provided. No particular draft gear is meant to be suggested, the provision shown merely indicating that the draft is to come direct to the center sills.



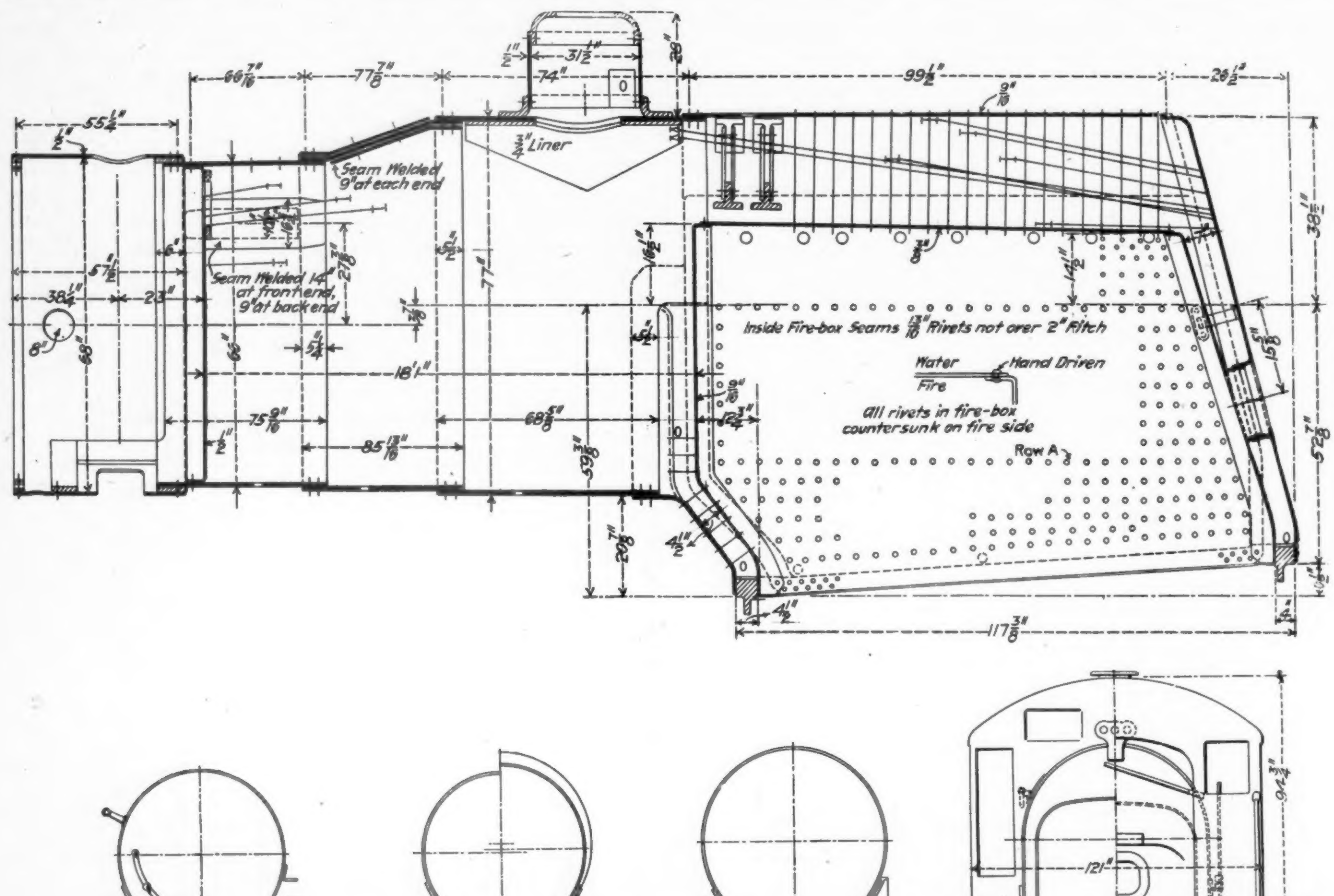
A STEEL-FRAME BOX CAR—BY C. A. SELEY.

The upper framing shown has several strong points. The ends are very strong and will not give away readily to the pounding of a shifting load. The sides are strong to resist lateral bulging under flowing loads. The vertical strength of the center sills and side framing is sufficient to carry a load of 88,000 lbs. without undue deflection, and, in fact, the vertical deflection of the sides of these cars is not noticeable under full loads.

An incidental point of advantage in cars with steel truss sides is their stiffness to resist racking of the body and roof, and this will lessen in a marked degree the necessity for renailing the siding and roofing, a class of repairs much called for with weak superstructures.

Now, as to whether the use of steel as above described is justified as against the use of wood is clearly one of the markets and delivery and not of mechanical adaptability. There are manifest advantages in favor of steel in the way of reduc-

tion of dead weight which contributes to the carrying of an increased percentage of paying loads, also a reduction of maintenance charges due to the structure being stronger and better able to resist shocks and loosening from wear. In case of wreck there is a great amount of salvage, as bent and twisted members can be straightened and used again; whereas if of wood a renewal is required. In heavy repairs of wooden cars the new material cost will run from 60 to 75 per cent. of the total, while if steel is used the labor cost will be represented by the above figures; leaving but 25 to 40 per cent. as the cost of new material required, and in composite cars this is mainly for lumber and not steel. All these points should be carefully weighed and credited against the increased cost of a steel car over a wooden one, and if properly appreciated the writer believes that not only steel underframes, but side and end frames for all classes of cars are fully justified.



VAUCLAIN FOUR-CYLINDER BALANCED-COMPOUND LOCOMOTIVE

ATCHISON, TOPEKA & SANTA FE RAILWAY.

G. R. Henderson, *Superintendent Motive Power.* Baldwin Locomotive Works, *Builders.*

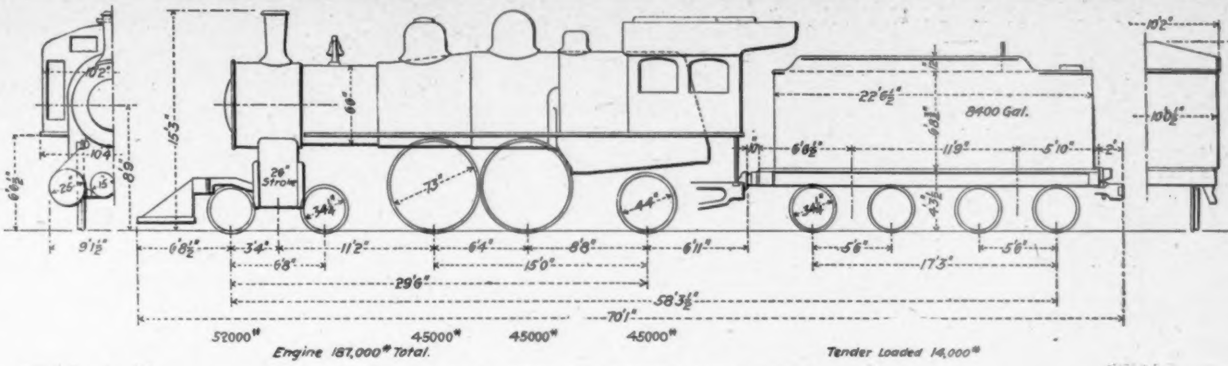
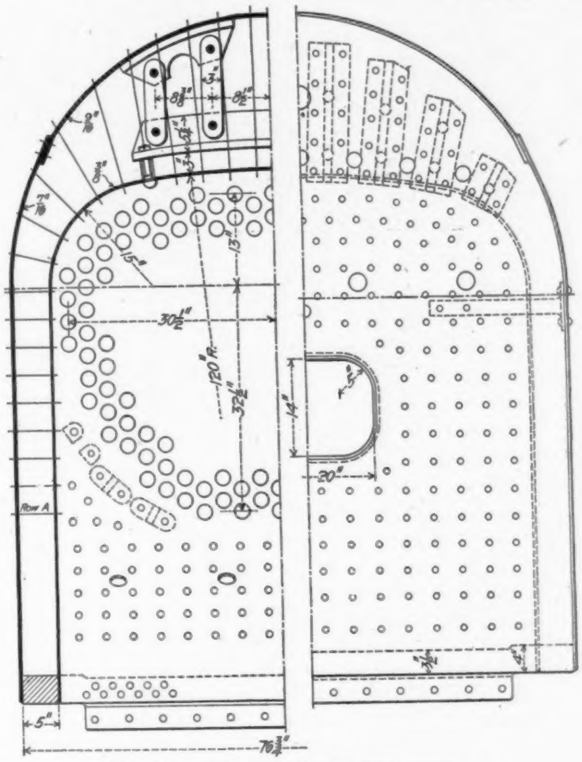
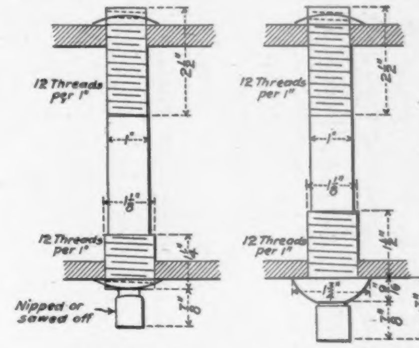


DIAGRAM OF LOCOMOTIVE AND TENDER.



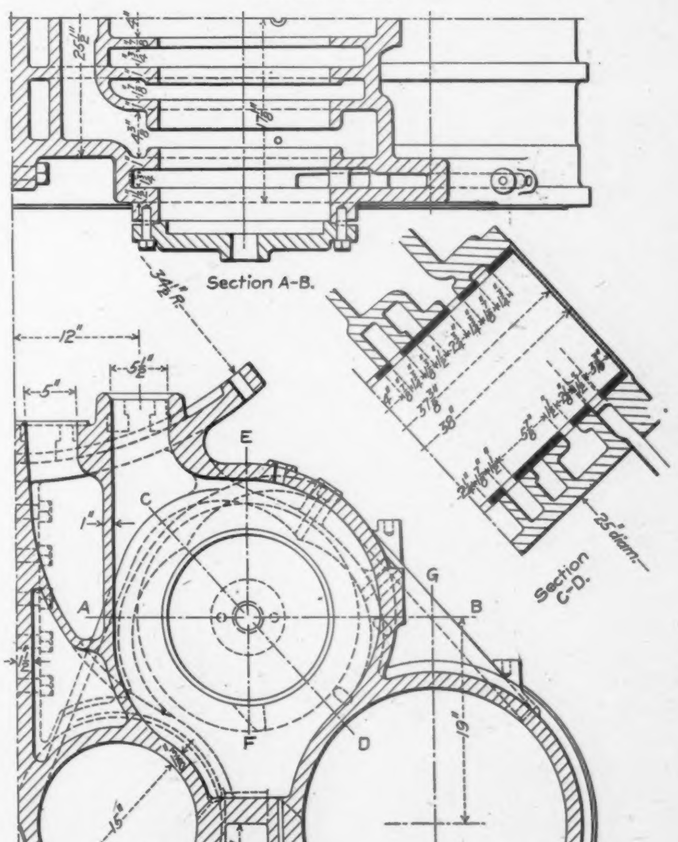
FIREBOX, SHOWING 5-IN. MUD RING.

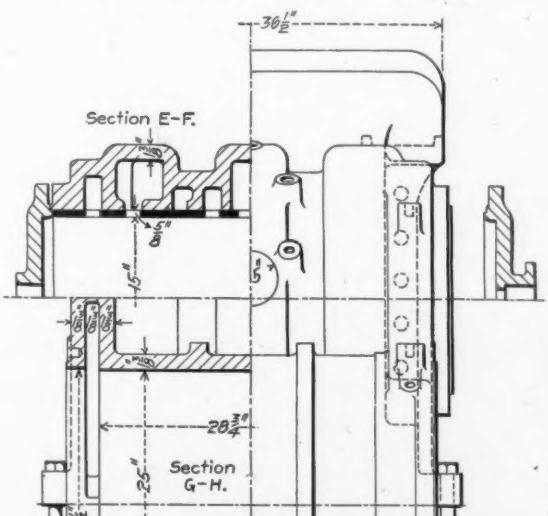


Style No. 1. ROWS OTHER THAN CENTER.

Style No. 2. CENTER ROWS.

CROWN STAYS.





CYLINDERS AND STEAM CHEST.

VAUCLAIN FOUR-CYLINDER BALANCED-COMPOUND LOCOMOTIVE.

ATCHISON TOPEKA & SANTA FE RAILWAY.

G. R. HENDERSON, *Superintendent Motive Power.* BALDWIN LOCOMOTIVE WORKS, *Builders.*

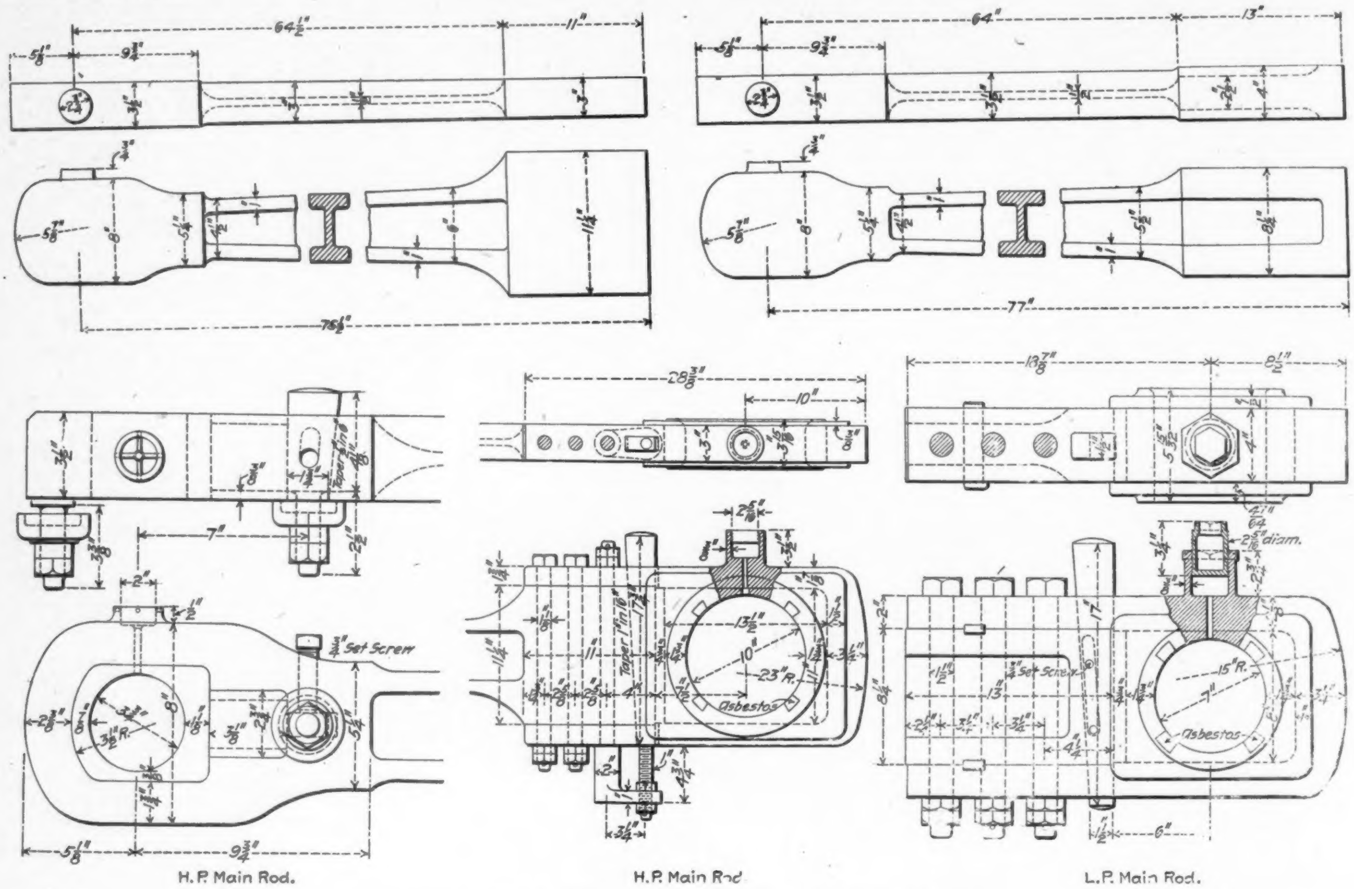
COMPOUND PASSENGER LOCOMOTIVES, 4-4-2 TYPE.

VAUCLAIN FOUR-CYLINDER BALANCED SYSTEM.

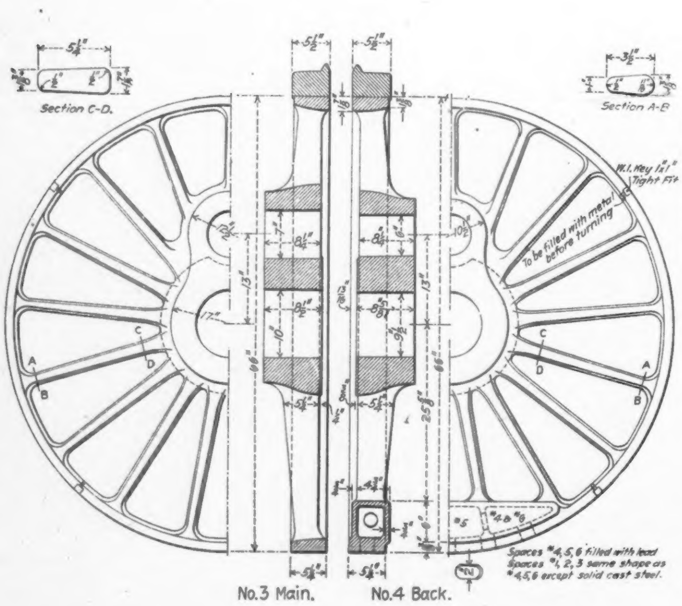
ATCHISON, TOPEKA & SANTA FE RAILWAY.

The Baldwin Locomotive Works are building, to their own design, four balanced compound locomotives for passenger service on the Santa Fe. Mr. G. R. Henderson, superintendent of motive power, has given his permission for the publication of this description.

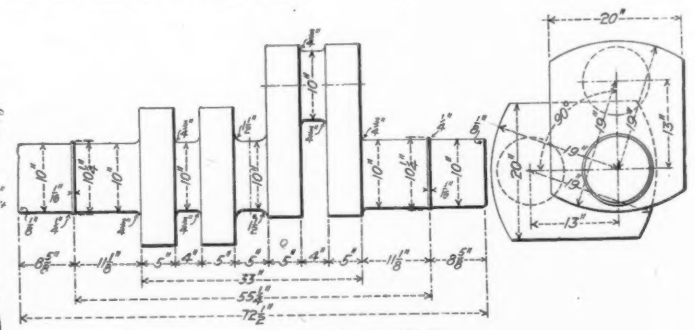
These engines are similar in many respects to the Plant System engine (AMERICAN ENGINEER, March, 1902, page 72). These are of the four-coupled type and have cylinders exactly like those of the earlier engine except as to minor details. The tractive power of the new design is 24,000 lbs. when working as a compound and the cylinders are approximately equivalent to 18.9 in. simple cylinders. The weight on drivers is to be 90,000 lbs., but with the balanced construction, undoubtedly a much greater weight than this can be placed on these wheels without more—and probably very much less—injury to the track than would be caused by a locomotive of the usual sys-



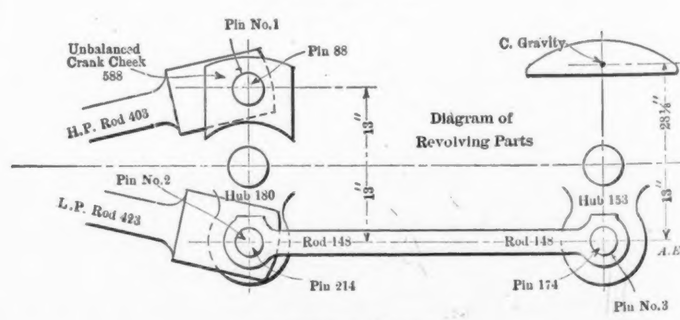
THESE DRAWINGS ILLUSTRATE THE LIGHTNESS OF THE RODS.



MAIN AND REAR DRIVING WHEELS.



THE CRANK AXLE.



COUNTERBALANCING.

VAUCLAIN FOUR-CYLINDER BALANCED-COMPOUND LOCOMOTIVE.

ATCHISON TOPEKA & SANTA FE RAILWAY.

G. R. HENDERSON, *Superintendent Motive Power.* BALDWIN LOCOMOTIVE WORKS, *Builders.*

tem of counterbalancing. The writer has long held the opinion that a self-balanced engine offered an opportunity to greatly increase the weight on driving wheels and thus obtain in the best possible way the advantages of a traction increaser which would be available all the time and yet not subject the track to more punishment than it now receives with the prevailing wheel weights. The advent of this construction upon a road like the Santa Fe is an event of great importance. We hope it marks a turning point in the development of American locomotive practice in favor of good balancing, the best possible use of steam and a division of the stresses among a larger number of parts of the running gear, which may therefore be made lighter and actually reduce repairs and failures.

Among the engravings is a preliminary diagram of the locomotive with its tender, which is a large one, carrying 8,400 gals. of water. The boiler is of the wide firebox type for coal burning. The mud ring is 5 in. wide at the sides, to assist circulation. While the tubes are 18 ft. long, the heating surface is 500 sq. ft. less than that of the 4-4-2 type locomotives on the New York Central. One of the drawings illustrates the crank axle, which differs in many respects from that used on the Plant System engine. The main bearings are 11⅛ x 10 ins., the crank pins 10 x 4 ins., the wheel fits 10 x 8⅝ ins. and the crank webs 20 in. wide by 5 in. thick.

The method of balancing and the remarkably light weights employed are clearly indicated in the sketch and the drawing of the driving wheels. A summary of the revolving weights referred to in the sketch is as follows:

REVOLVING WEIGHTS.

Pin No. 1. Inside. lbs.	Pin No. 2. Outside. lbs.	Pin No. 3. lbs.
403	423	...
588	180	153
88	214	174
...	148	148
1,079	965	475

This leaves 1,079, minus 965, or 114 lbs. excess revolving weight on the inside of the main wheel. The reciprocating weights are as follows:

RECIPROCATING PARTS.

	Inside.	Outside.
Piston	356	463
Crosshead	310	310
Main rod on crosshead pin	149	156
Totals	815	924

This leaves 929, minus 815, or 114 lbs. of reciprocating weight in the main wheel. The 114 lbs. of reciprocating weights are balanced in the main wheel by 114 lbs. excess revolving weight inside the main wheel, thus requiring no counterbalance in that wheel. The balance for 475 lbs. is required in the rear wheel and this is accomplished by a weight of 208 lbs. with a radius of 28½ in., as indicated in the diagram.

Ratios.

Heating surface to volume of high pressure cylinders	= 571
Tractive weight to heating surface	= 29.7
Tractive weight to tractive effort	= 3.75
Tractive effort to heating surface	= 7.92
Heating surface to grate area	= 61.3
Tractive effort × diameter of drivers to heating surface	= 578.
Heating surface to tractive effort	= 12.6%
Total weight to heating surface	= 61.7

VAUCLAIN 4-CYLINDER BALANCED COMPOUND PASSENGER LOCOMOTIVE.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

Gauge	4 ft. 8½ ins.
Cylinder	15 and 25 x 26 ins.
Valve	Balance piston
Boiler—Type.	Wagon top
Diameter	66 ins.
Thickness of sheets	11/16 and 13/16 ins.
Working pressure	220 lbs.
Fuel	Soft coal
Staying	Radial
Firebox—Material	Steel
Length	107 15/16 ins.; width, 66 ins.
Depth	front, 75⅞ ins.; back, 67⅜ ins.
Thickness of sheets	sides, ⅜; back, ⅜; crown, ⅜; tube, 7/16 in.
Water space	front, 4½ ins.; sides, 5 ins.; back, 4 ins.
Tubes—Material	Iron; wire gauge No. 11
Number	273; diameter, 2¼ ins.; back, 4 ins.
Heating surface—Firebox	190 sq. ft.
Tubes	2,839 sq. ft.
Total	3,029 sq. ft.
Grate area	49.4 sq. ft.
Driving wheels—Diameter outside	73 ins.
Diameter of center	66 ins.
Journals	main, 10 x 11 ins.; others, 9 x 12 ins.
Engine truck wheels—Diameter	34¼ ins.
Journals	6 x 10 ins.
Trailing wheels—Diameter	44 ins.
Journals	8 x 12 ins.
Wheel base—Driving	6 ft. 4 ins.
Rigid	15 ft.
Total engine	29 ft. 6 ins.
Total engine and tender	58 ft. 3½ ins.
Weight—On driving wheels	90,000 lbs.
On truck, front	52,000 lbs.
On trailing wheels, estimate	45,000 lbs.
Total engine	187,000 lbs.
Total engine and tender, about	327,000 lbs.
Tank—Capacity	8,400 gals.
Tender—Wheels	No. 8; diameter, 34¼ ins.
Journals	5½ x 10 ins.

STEEL UNDERFRAMES AND STEEL CARS.

A BUSINESS QUESTION.

Does it pay, from a business standpoint, to build cars of 80,000 lbs. capacity and over with wooden underframes?

The Baltimore & Ohio Railroad Company.
Office of General Superintendent of Motive Power.

If I had to pay for equipment out of my own pocket, I would certainly build cars of forty tons capacity and over, with metal underframes. From personal observation, I am satisfied that the life of a car with wooden frames, no matter how strongly built, will be very short; also that it will suffer considerable damage when mixed with steel cars in the long and heavy trains that are hauled by modern locomotives. That the cost of repairs of steel cars will be less than that of wooden cars I have no doubt whatever, and the experience we have had so far confirms this view. Of course, cars with steel underframes have not been in service as long as is the case with wooden cars, and when they advance in age the cost of maintenance will undoubtedly be greater than it is during the first few years of their life. I think, however, it is perfectly safe to predict that the final cost will be considerably less for the steel cars than for the others. F. D. CASANAVE,
General Superintendent Motive Power.

New York Central & Hudson River Railroad.
Office of General Superintendent Motive Power, Rolling Stock and Machinery.

I would say in a general way, that I think we cannot much longer delay the use of the steel underframe, and it also looks as though the upper structure of cars would tend toward steel.

J. F. DEEMS,
General Superintendent Motive Power, Rolling Stock and Machinery.

Erie Railroad Company.
Office Mechanical Superintendent.

The time has passed when steel construction should be considered experimental. I cannot indicate, however, that for cars of 80,000 lbs. capacity we should yet depart from wood underframes, as the first cost and type of construction have appealed to me as good practice up to the present time. For anything over 80,000 lbs. capacity we are in favor of encouraging and adopting steel for underframes. The greatest objection to steel construction in the past and, I may say, even at the present time, is in the design and arrangement for securing the box to the steel underframe in box cars. We think, however, that this can be overcome, and the 100,000-lb capacity car of the future should embody in its make-up, so far as possible, a type of metal construction, which, from our point of view, is quite as essential in a box car as in other cars.

W. S. MORRIS,
Mechanical Superintendent.

Southern Pacific Company.
Office of General Superintendent Motive Power.

We have as yet had no personal experience with steel cars, although we are now having some 3,100 cars built with pressed steel underframes. I believe the steel underframe has come to stay. At a meeting of the motive-power officers of all of the Harriman lines, now in session here, after considerable discussion of this matter it was decided to adopt steel underframes for all future freight equipment. H. J. SMALL,
General Superintendent Motive Power.

Chicago, Milwaukee & St. Paul Railway Company.
Office of the General Superintendent.

My experience and observation in the matter of metal underframes for cars are not sufficient to express a decided opinion. With the cars with which I have had experience I would say that the maintenance of the metal underframe is materially greater than without. It is possible and, I think, probable that it is more a matter of design, and I question whether the details of design are yet sufficiently worked out and demonstrated, but there are several cars of various designs in service now, and I think they will enable us to settle this question in the course of a few years. J. N. BARR,
General Superintendent.

Grand Trunk Railway.
Office of Third Vice-President.

In view of the fact that this company has not operated any steel cars or cars with steel underframing, I am unable to speak from any personal experience. Our opinion is that it is economy to construct cars up to and including those of a capacity of 40 tons, of wood, but that on cars with a capacity of more than 40 tons, it would prove economy to use the steel underframing; and in coal cars, where the car is a hopper, self-clearing type, steel throughout is desirable. As this company now has on order steel cars of 50 tons capacity, we will be able later on to speak from practical experience.
FRANK W. MORSE,
Third Vice-President.

The Delaware, Lackawanna & Western Railroad Co.
Office of Superintendent Motive Power and Equipment.

I would say that, as a general proposition, the time has arrived for substituting steel for wooden construction in the underframe of all cars of 40-ton capacity and over. In regard to the box cars, of which I have any knowledge, built with the steel underframe, I think the wooden sills now used as a foundation for the box of the car are too light. We have had several cars of this type in our shops for repairs, and found the wooden sills on top of the steel underframe had split, and, in my opinion, if these cars had a combination Z-bar and 4 x 8-in. outside sill for holding the frame of the box, the car wou'd be very much improved. T. S. LLOYD,
Superintendent Motive Power and Equipment.

The Chicago & Alton Railway Company.
Motive Power Department.

Our standard for all box, furniture, stock and refrigerator cars of 60,000 lbs. capacity and over is steel underframing.

After a test of nearly four years we have come to the conclusion that the steel underframing is a decided success, and in my opinion, with steel cars, equipped with strong and suitable draft gear and steel trucks, very little, if any, running repairs will be needed. My experience has been that it is almost impossible to construct a draft gear on a wooden car which will withstand the shocks and strains to which a car is subjected in the heavy tonnage trains of to-day. I realize that serious objections have been raised to the steel sides and floors on gondolas on account of corrosion. This is not, in my opinion, as serious as is claimed; nor will the corrosion equal the running repairs that are necessary on wooden cars. At any rate, the corrosion objection cannot be made against steel underframing. A. L. HUMPHREY,
Superintendent Motive Power.

Atchison, Topeka & Santa Fe Railway.
Motive Power Department.

I think there is no question but what steel underframes are specially desirable for large capacity cars. With cars of less than 80,000 pounds capacity it is practically impossible to design a steel underframe which will be as light as the ordinarily adopted wooden frame, but when the capacity reaches 80,000 pounds it can be done without difficulty, and as the capacity is still more increased the advantage will be unquestionably with the steel underframing. The ordinary freight cars in this country adapt themselves very conveniently to steel underframing, and there have been hopper bottom gondolas, drop bottom gondolas, box cars, and practically all varieties built with this framing. With stock cars it seems in a measure undesirable on account of the drippings from the cars having an action upon the metal parts and tending to quickly corrode them, but there are very few stock cars that are built of over 60,000 pounds capacity. We have very little information that would show us positively the advantage in dollars and cents of the steel frame car over the wooden car in the way of repairs, but we know from experience that under ordinary service and with the ordinary care in protecting them from rust and corrosion that the frames will last very much longer than wooden frames, which are subject to decay and checking. The heavy pulling strains induced in the drafts of freight cars by the large locomotives of the present day more than ever make this type of car desirable, and particularly as center sills can be obtained of sufficient depth to embody the draft rigging and also to take the pressure from the buffer blocks, when cars are so provided. Taking all points into consideration, we think there is no question but for large capacity cars—that is over 60,000 pounds, and some times with 60,000 pounds—the advantages are greatly in favor of the steel frame car. G. R. HENDERSON,
Superintendent Motive Power.

——— Railroad.
Office of Superintendent Motive Power.

I hardly believe that the subject is open to discussion. The experience all roads are having who are using the large steel 100,000 lbs. capacity cars is that they are very hard on the lighter wooden cars, and the only way I see in which we can permanently save our lighter cars is by substituting steel center sills with the same heavy draft gear as used on our 100,000 lbs. capacity cars. We are doing this at the present time in our 60,000 lbs. capacity coal cars. It costs us quite a little money, but we nevertheless feel that we are justified in doing it, as the only salvation the old wooden car has is in having the same strength through the center sills and draft gear that the heavier car has. In other words, I do not believe it is possible to design a car and have things in proportion to the capacity of the car, but believe that the center sills and the draft rigging have got to be made the same on the 60,000 lbs. capacity car that we have on the 100,000 lbs. car if we expect them to run in the same trains and stand the same hard usage. It is only one step further to substituting an entire steel underframing for all cars. This we intend to do in all new work, and in all repair work where the cars are running in trains that have the heavy 100,000-lb capacity cars in right along. On the ——— ——— Railroad we have no box cars over 80,000 lbs. capacity—and comparatively few of them—so that it is not immediately necessary to go into the steel underframing in this class of car, although all new cars that we are having built are built on these lines. With the coal car the situation is entirely different, as we run solid trains from the ——— and ——— regions to tide water, and a large percentage of the cars in these trains are the regular 100,000 lbs. capacity steel car, and it is becoming very apparent that the life of our ordinary wooden car is going to be very much reduced unless the matter is taken in hand very promptly and steel center sills substituted for the present wooden construction.
— — ———,
Superintendent Motive Power.

The Pittsburgh & Lake Erie Railroad Company.

Unquestionably the steel underframe is a good thing, but I believe that it is neither necessary nor economical to use it under cars of less than 80,000 lbs. capacity. We believe that cars of 40,000, 50,000 and 60,000 lbs. capacity can be built on wood frames of sufficient strength and at a much smaller cost, but for any heavier capacity it is undoubtedly wise to use steel underframes. These remarks are purely an opinion, and are not based on actual observance. While this company has a large equipment of all-steel cars, we have none with a steel underframe only. L. H. TURNER,

Superintendent Motive Power.

New York Central & Hudson River Railroad Company.

[EDITOR'S NOTE.—This letter was written before Mr. Waitt severed his connection with this road.]

In my opinion, the time has not come to take the position absolutely that steel should be substituted for wood for underframes of cars. I think, however, that such a change is desirable and is in the line of ultimate economy. Personally, I am so well convinced of the desirability of this change that I should have no hesitation in recommending and advocating the steel underframe on new freight cars of 40 tons capacity and over. Experience is rapidly being developed with steel underframes which will undoubtedly clearly demonstrate that, even with slightly greater first cost, the net result due to less expense in repairs, and greater value of scrap, is decidedly in favor of the steel underframe. The steel underframe can be designed to give lighter weight with greater strength, and the steel sills can be protected so as to reduce the depreciation from corrosion to a small feature, which, as compared with decay of wood, will show the advantage in favor of steel. A steel underframe makes possible much greater stability in design for draft rigging, which in wooden cars is a source of heavy expense for repairs. In designing cars with steel underframes particular attention should be given to providing for good protective features against corrosion. If steel is given a protective coating, care should be taken in the design to prevent friction from slight moving of parts which would in any way destroy the coating. It is also desirable to as far as possible give easy access to as much of the metal as possible for inspection, cleaning and painting. In conclusion, I believe the steel underframe is the coming type, and that it is coming to stay. A. M. WAITT,

Superintendent Motive Power and Rolling Stock.

Burlington & Missouri River Railroad in Nebraska.

Office of Superintendent Motive Power.

I have come to believe that the steel car is much better than the wooden construction. The steel underframing has much in its favor. It appears to me that the steel underframing will last for an almost indefinite time under box cars. The draft rigging can be attached in a more rigid and permanent way on steel cars than is possible on wooden construction, and with the present double-spring rigging the annoyance and cost of repairs due to failure of draft rigging should almost entirely disappear. Of course, cars are not built to be wrecked, but the experience with the steel underframe cars has shown that they are not nearly so easily damaged in a wreck as are the wooden cars. I am in some doubt as concerns the steel underframing for coal cars. The question here seems to me to be whether the wooden sill will rot out quicker than a steel sill will rust out. In the case of coal cars, both classes of sills are exposed to the weather. On the whole, I believe that the steel underframing is also the most desirable in coal cars. It does not seem to be so much a question of the desirability of steel underframing, but rather how soon can we get them and get ourselves in shape to take care of them. I am very strongly in favor of an underframing made of merchant shapes. I believe cars built of these shapes are cheaper to repair than those made of special sections, and again, the material can be obtained more readily. R. D. SMITH,

Superintendent Motive Power.

——— Railroad.

Office of the General Manager.

We are preparing designs of steel underframes for the various types of our freight cars as rapidly as possible, with the intention of eventually using the steel underframe construction for all new cars. As this is an evolution as a result of a number of years' study and experience, it is about as good evidence as you could have that in our judgment it is a good business proposition to discard wood for steel for underframes.

— — ———,

General Manager.

Burlington & Missouri River Railroad in Nebraska.

Office of Assistant General Superintendent.

It seems to me that for a great deal of freight the concentration of loads into fewer units is so advantageous from a train-tonnage and traffic-handling standpoint that there can be little question as to the wisdom of using steel members for underframes. Steel bridges have entirely taken the place of wooden bridges, and I believe that, with the heavier loads and with the consequent heavier shocks that our equipment now receives, steel underframes will undoubtedly be regarded in future as the proper material for most of our freight-car equipment. G. W. RHODES,

Assistant General Superintendent.

Canadian Pacific Railway Company.

Mechanical Department.

I referred your letter in connection with steel car construction to our master car builder, and he has answered me as follows:

"I would say that in my opinion steel underframes, with or without truss-rods, are very desirable for freight cars of 40 tons capacity or over. Wood is becoming more difficult to obtain every year, and when obtained is almost always unseasoned and more or less defective, and in consequence the floor frames of all classes of freight cars lose shape as well as strength, and deteriorate very rapidly. It would appear from the great demand for steel floor frames at the present time that the only reason they are not more extensively used is the difficulty of obtaining them fast enough. The steel-frame car has shown its reliability as well as its ability to withstand severe shocks and derailment, and in view of the fact that repairs to it amount to nothing except in cases of accident or derailment, any reasonable expenditure in this direction is in the line of economy. The pressed steel frame, being practically the pioneer, is in very extended use, and would appear to be very desirable as long as it keeps out of trouble, but when from any cause the frame becomes distorted it appears to be an absolute necessity to return the car to the builders for repairs. The steel floor frame built from merchant rolled sections, while possibly more expensive at the outset and somewhat heavier, obviates these objections. But there have been many mistakes made in building steel frames, on account of improper distribution of material. In addition to this, there have been many mistakes made in the way of unnecessary dead weight. There is no doubt in my mind, however, that the steel floor frame has come to stay, and that the freight car of five years hence will have not only steel floor frames but quite likely steel upper frames. In connection with the steel floor frame, a good friction draft rigging should make it possible to operate cars with practically no repairs. The greatest enemy the steel floor frame has at the present time is rust, and with the many efforts now being made to secure something that will prevent this, there can be no doubt that science will produce something which will remove this last objection and make the steel floor frame an unqualified success."

I will add that I fully concur with Mr. Fowler's views in this matter. We have casually considered the question of steel underframes for our future new equipment, but we have decided that for the present at least we will not change from wood construction. E. A. WILLIAMS,

Superintendent Rolling Stock.

Michigan Central Railroad Company.
Office of Superintendent Motive Power and Equipment.

In my opinion, the underframes of 50-ton cars and upward should be made of steel. In regard to 40-ton cars, I am not sure. Figures from the manufacturers show that our 40-ton box car would cost from $100 to $125 more per car with steel than with wooden underframes. I am inclined to think that the difference in the cost of maintenance would not warrant this.
E. D. BRONNER,
Superintendent Motive Power and Equipment.

Seaboard Air Line Railway.
Office of Superintendent Motive Power.

It was my privilege to be one of the pioneers in the matter of steel car frames for freight-car use, excepting the Harvey car, and the pipe-framed car, neither of which designs was successful, owing to the fact that they were principally based on a substitution of metal for wood, following the original design and pattern intended for a wooden car, and without due reference to the proper use of steel. The result of much investigation and close study on this subject has led me to feel positively certain that the underframes of all cars of 80,000 capacity and over should be built of steel, for the following reasons:

The steel frame made out of commercial shapes is lighter than the timber trussed frame of equal strength. The steel frame has less deflection under load and is not so easily distorted. The strength of the steel frame is not seriously interfered with by shrinkage, as is the case with the wooden frame. The steel frame, when properly constructed, does not require tightening up, but when once riveted together is complete for all time, barring accident. For hopper and gondola cars I believe strongly that the side framing should also be of steel, and I believe in the use of steel end posts in box cars, but do not believe in steel side trussing for box cars. With steel frames a better and more elastic draft gear is desired than with the wooden frames, to save the couplers from injury, as the harshness of the blow is much greater when struck by a rigid steel-framed car than by a wooden car, where the sills will yield a trifle at the instant of contact. Experience has shown that cars with properly built steel underframes cost very little for body repairs, and that the investment of a small amount of money in such metal underframes pays a handsome interest in reducing the cost of maintenance.
R. P. C. SANDERSON,
Superintendent Motive Power.

Maine Central Railroad Company.
Office of Superintendent Motive Power.

My experience with steel cars, and also with cars of over 30 tons capacity, is limited, since the road with which I am connected owns no such cars. We have, however, at the present time a good many foreign cars, both of large capacity and of steel construction, running over our road, and since almost all of them are practically new cars, they give us very little trouble. Almost all the wooden cars of 40 tons capacity are box cars, and thus far I do not see that they are developing any such weakness as would justify the conclusion that all wooden construction is unfit for box cars of this capacity. Almost all the flat and gondola cars of over 30 tons capacity which we handle have steel underframes, and we have not yet found that these steel underframes require any repairs. My own feeling in the matter is that a well-constructed wooden box car of 60,000 to 80,000 lbs. capacity will give excellent satisfaction and prove durable under existing conditions of service. In spite of the hard treatment to which freight cars are subjected in freight yards, I do not find that our own 30-ton capacity wooden box cars built in the last three years are going to pieces in a serious way, and I question whether the very considerable difference in cost of the higher capacity box cars with steel underframes is justified by the difference in the cost of maintenance. In the case of gondola and flat cars, it seems to me that the question is very different. It may be possible to build a wooden flat car which will successfully withstand the treatment to which cars are subject, but I am doubtful in regard to it, and I believe that a good steel flat car is distinctly a good investment to-day. Where the conditions of service make hopper or self-discharging coal cars desirable it seems to me that the higher capacity steel car is the proper thing, although the question of expense in maintaining the steel superstructure of coal cars is one which requires more experience and careful consideration.
P. M. HAMMETT,
Superintendent Motive Power.

——— & ——— Railroad.
Office of Master Car Builder.

I have not yet taken very kindly to steel cars, and especially to that class of steel cars that carry coal. I think none of them have been in service long enough yet to test their economy as compared with a first-class wooden car. I mean so far as concerns the deterioration of the metal caused by sulphur, acids, rust, etc. It is barely possible that our railroading in this section is not severe enough to pay the extra cost of metal cars, and that may bias my opinion somewhat. I certainly believe that a metal car, so long as it does not seriously rust or become weakened by sulphur or chemicals, will, in the same class of service, be maintained at a lower cost of repairs than the ordinary wooden car. Time will tell whether or not I am right on this subject. I have no objection to your making use of this letter, except that I do not wish its author quoted.
— — ———,
Master Car Builder.

Butte, Anaconda & Pacific Railway Company.
Office of Vice-President and General Manager.

Our experience in the handling of copper ores and smelter supplies has taught us that a wooden car will not stand up under the tests necessary to subject them to. We use the pressed steel cars of 100,000 lbs. capacity for ore and other smelter material, and do not find any noticeable deterioration by reason of corrosion. We paint interiors of cars used in flue dust service. The only serious problem in the use of large-capacity steel cars is the development of sharp flanges, caused by the sagging of bolsters, the load being carried on side bearings and preventing proper curvature of trucks. The distance between side bearings has been increased, but does not afford the necessary remedy, as in the course of a few weeks the bolster sags to its old position. We are experimenting with different forms of side bearings that will engage the load but permit proper curvature of trucks. Whether or not we can solve the problem is entirely a matter of conjecture.
M. S. DEAN,
Vice-President and General Manager.

——— Railroad.
Motive Power Department.

While we have not been users of metal underframing to any extent, we have had considerable experience with it on cars belonging to other companies, and from what I have seen of it, I am firmly of the opinion that the time has not arrived for such a change, excepting the use of metal for center sills only. We have used wooden underframing with metal center sills to a very great extent with complete success. I believe it would be to the interest of railroad companies to construct certain classes of freight cars with steel center sills in the wooden underframe, such metal sills to be so arranged that the strains of pulling and buffing will come in direct line with the couplers. There are other classes of cars, such as ore cars, which are very short in construction, and can be built cheaper with wooden underframe, which, if properly constructed, taking the corrosion into consideration, will, I believe, outlast the metal underframe made of present weights. We have had 200 50-ton capacity ore cars in service since April, 1900, and in the following year the number was increased to 600, all having wooden construction throughout, and up to the present writing we have spent practically nothing for maintenance of these cars. As to box cars: I think it a well-established fact that wooden sides and intermediate sills will, barring accident, last from twelve to twenty years, and metal sills will become

useless from corrosion before this length of time. Where metal underframes are used in the construction of a box car I know of no way the braces can be applied to perform the same service given in wooden underframe cars. Where the latter are properly constructed the camber is put in with the braces, and the seasoning of the sill and plate will bring the settlement on the braces, but it will not settle below a straight line, and the upper part of the car is therefore held firmly in position. This feature cannot be obtained where the underframing is of metal, because there is no camber in the car when built, and when the roof-plate and the wooden rests for posts and braces season a little there will be no settlement, as in the case of the wooden underframe car, and the consequence is that the braces become loose, allowing the top portion of the car to work, and this working and racking is very detrimental. The roof, sides, doors, floor, posts, braces and, in fact, the whole portion of the car above the sills, as well as the couplers, springs, followers, draw-lugs, trucks, bolsters, air-brakes and fittings, will depreciate as much where the underframing of the car is of metal as it will in the case of a wooden underframe, so that the only portion on which the depreciation will differ will be in the underframing itself.

— — ———,
Master Car Builder.

——— & ——— Railroad.
Office of Superintendent Motive Power.

I think we have arrived at the time when the wooden underframing will be largely superseded by steel from the fact that with engines of tractive power running from 40,000 to 60,000 lbs. it is impossible to get a satisfactory wooden structure to stand the racket induced by such heavy strains either in tension or compression; even if the wooden underframing construction is to be perpetuated it would seem as absolutely necessary that some central member of steel be embodied in that construction to provide for the longitudinal strains of tension and compression. If a railroad is entirely circumscribed with its own business and does not interchange, and the motive power is not of the increasing capacity of the day, a wooden underframe construction might be perpetuated, but for interchange business all over the country I believe that a wooden underframe in new construction will soon be a thing of the past.

— — ———,
Superintendent Motive Power.

Chicago Great Western Railway.
Office of Superintendent Motive Power.

I have had no experience with steel underframe cars of any capacity, nor wooden cars of a capacity greater than 35 tons, and not having an accurate distribution of cost of maintenance of wooden cars under 40 tons, I have some hesitation in attempting to answer the question.

To consider the question as related to 30 and 35-ton cars, it may be assumed that wood and steel underframe box cars have the same light weight; that wooden cars cost $800 and steel underframe cars $950;, that depreciation of a wooden car is 5 per cent. and of a steel car 3 per cent. per annum; that the cost of maintenance of wooden cars of good construction is as follows:

	Material per car year.	Labor per car per year.	Total per car per year.	Total per 100 miles.
Sills	$ .50	$ .50	$1.00	.014
Couplers	1.00	.50	1.50	.022
Draft timbers	1.50	1.00	2.50	.036
D. B. pockets	.70	1.30	1.00	.014
Other repairs and wrecks	....	....	15.00	.214
Total	11.00	10.00	21.00	.300

It is also assumed that the breakage of steel sills will be less than that of wooden sills, but that on account of greater rigidity there will be more broken couplers with steel sills and that it will be necessary to paint steel sills more frequently to prevent corrosion; that the cost of maintenance of the steel cars will be the same as that of the wooden cars, less draft timbers and sills, or say 25 cents per 100 miles; that the average mileage of wooden cars in service (that is, not held for repairs) is 7,300 miles per year; that 5 per cent. of the wooden cars are constantly on the repair track; that the number of steel cars on repair tracks is less in proportion as repairs per mile are less, or say 4 per cent. Therefore, an investment in 1.05 wooden cars, or $840, is necessary, and in 1.04 steel cars, or $988, to make 7,300 miles per year. Therefore, we have for the wooden car:

$840 at 10% (5% interest and 5% depreciation)	$ 84.00	
Repairs, 7,300 miles at 30 cents	21.90	
Total		$105.90
And for the steel cars:		
$988 at 8% (5% interest and 3% depreciation)	$ 79.04	
Repairs, 7,300 miles at 25 cents	18.25	
		97.29
		$8.61

a saving in favor of steel car per year of $8.61, or about 8 per cent.

It would seem from these figures that the percentage of total repairs to be saved by use of steel underframes is too small and uncertain to justify the additional investment of 20 per cent. in first cost in cars of 30 and 35-ton capacity. As the capacity increases I presume the cost of maintenance of wooden cars would increase more rapidly than that of steel cars, and that there would be a farther saving in the use of steel cars by reason of their lighter weight for a given capacity. The loss by wrecks is no doubt less with steel cars on account of less cars totally destroyed, but there are no doubt a good many cases of partial damage where broken sills are easily replaced, whereas bent and distorted steel sills are expensive to straighten or renew. Experience with steel tender frames, steel trucks and steel brake-beams indicates that corrosion is quite rapid unless they are kept painted. The damage to underframing of wooden cars is largely due to concentration of shocks at the center sills or draft timbers, and I believe that the serviceability of wooden underframing can be materially improved if the jerks and blows can be more uniformly distributed to all the sills.

DAVID VAN ALSTYNE,
Superintendent Motive Power.

Santa Fe Coast Lines.
Motive Power Department.

My first experience with the all-metal car was on the Norfolk & Southern Railroad where we had a lot of iron pipe cars, leased from the Southern Car Company, and which, under the conditions then existing on that railroad, where we had very small grades and light engines (not over 18-in. cylinders), the cars gave splendid service compared with the wooden cars, which gave us a great deal of trouble by rotting, and which, in consequence, we were always rebuilding or putting in two or three new sills with the ensuing large expense. The first thing we noticed was that the iron pipe cars were very seldom in the shop for repairs, in fact, hardly ever there unless they had got into a wreck. We then began to inquire whether they were not less expensive for maintenance and repair than the wooden cars, and tried to find out by keeping the exact cost of repairing these cars and a series of wooden cars of about the same age, and found, if I remember rightly, the wooden cars cost eight times as much to keep in repair. As soon as we were satisfied on this point we started to design cars made of commercial shapes and which could be more easily put together and easier to maintain than the pipe cars, which required a large number of special parts for repairs. We tried to make a design as simple as possible, and, in fact, the body of the car was nothing further than commercial shapes cut to length and fastened together, and the usual truss rods applied underneath the car. These cars were fully described in a paper read before the New York Railroad Club about ten years ago. The figures given in the paper showing comparative cost of repairs between the wooden and metal cars were, I think, a great surprise and, I believe, the first figures made public giving this information. The pipe cars referred to were 40,000 capacity, if I remember correctly, while the new cars designed by the Norfolk & Southern were 60,000 lbs. The first of the Norfolk & Southern cars were built about 1892, and I know that during the next six or seven years, while I was with the road, this car was positively as good as new. It had been kept painted, was well able to carry its load and had not got into any wreck, so that every time the car was repainted it was impossible for anyone to distinguish, by examination, whether the metal frame was a

new or old one. It was this main fact which encouraged us to build some more steel cars, and some were built by the Baltimore Car Works about 1896, all of which gave splendid service, and, I believe, are still giving perfect satisfaction. About a year ago, however, I heard that the first car built had just been in a bad wreck, but whether it was totally destroyed or not I cannot say.

These cars were designed with capacity equal to the largest cars made in those days and which were, and still are, enough for the traffic which exists in that part of the country. The great developments in design and capacity made by Mr. Schoen and his associates in the Pressed Steel Car Company were not thought of, and the step taken by them was, of course, a most important one in the development of the steel car question, and was, I presume, brought about by the opportunity presented in hauling ore to the furnaces.

While designing the cars for the Norfolk & Southern Railroad I learned that the making of steel cars for freight service was a common practice in Germany and some of the other European countries, and that they were so successful that the officers of the roads would not think of returning to the use of wood, and I hold strongly to the opinion that all railroad companies should use steel underframes instead of wooden ones, and I believe that while the first cost is greater, the yearly cost of maintenance and renewals would be very much decreased while the life of the car would be prolonged to an indefinite period, only provided that the metal is kept constantly and properly covered with paint.

G. R. JOUGHINS,
Mechanical Superintendent.

Norfolk & Southern Railroad Company.

The six flat cars designed by Mr. Joughins, and built under his personal supervision, have given excellent service and are still doing so. Some cars of similar design that were afterward built by contract have not been so satisfactory, due to lack of due care in construction and the use of light material. Turned bolts were used by Mr. Joughins in the construction of his cars, and great care taken in fitting the parts together properly, and the wisdom of so doing is shown by their present condition, the six original cars being now in practically perfect condition while the contract cars are giving more or less trouble. The cost of repairs has been principally for painting and decking. The cars have been used for hauling pine logs almost exclusively, and the decking being of pine 1¼ in. thick, and the space between the side and intermediate sill unusually wide, have necessitated frequent renewal of broken decking. I think the decking should have been oak 3 in. thick. The average cost of the six cars built by this company, for the five years ending January 31, 1903, has been $9.25 per car per year, including cost of journal bearings, repairs to air brakes and couplers, decking, painting, etc. The amount expended on the steel car proper has been very small indeed.

JOHN WHITESTONE,
Acting Superintendent Motive Power.

Central Railroad Company of New Jersey.
Office Superintendent Motive Power.

We received 1,000 steel hopper cars of the pressed steel type in April, 1901. These have cost us since for repairs about $10.60 per car annually, distributed as follows:

Details.	1901.	1902.	1903.	Total.
Bodies exclusive of body bolsters	$129.66	$2,473.97	$100.74	$2,704.37
Body bolsters	....	15.01	......	15.01
Sills	....	74.39	22.82	97.21
Draft rigging, exclusive of couplers	....	1.22	......	1.22
Couplers and knuckles	202.83	837.04	588.74	1,628.61
Hoppers and attachments	12.88	137.46	32.50	182,84
Brake, piping and attachments	2,686.53	1,718.97	230.28	4,635.78
Trucks, exclusive of wheels, axles and truck bolsters	1,235.96	520.82	247.75	2,004.53
Wheels and axles	306.41	496.11	279.63	1,082.15
Truck bolsters	384.27	10.08	......	394.35
Journal bearings and keys	180.37	284.40	16.33	481.10
Hand holds and steps	6.04	18.57	......	24.61

This includes a lot of painting. Cars properly painted at the car works should not require paint of any kind before two years of service. Regardless of the cost of suitable wood for car construction, the steel underframing finds favor on account of the additional strength given per pound of dead weight, which is considerable. We are so confident of this that our orders for cars this season embracing steel underframing amount to 2,600. We feel that the time has arrived when only steel shapes of commercial form should be considered for this purpose. The figures we give you do not include the cost of repairs caused by accident, such as collisions or derailments. These cars required a large amount of rather expensive replacements which made the cost of maintenance abnormally high, in addition to the painting.

These cars at the present time are standing up nicely on their centers, and are giving no trouble on account of cut flanges. We feel convinced that the time has arrived to employ steel for underframing on all kinds of cars in place of wood. Our preference is largely in favor of structural steel for frames, and we have only used this form in the frames now building for this company. Our experience leads us to believe that repairs can be made at much less expense where structural steel is employed than where the pressed forms are used, and that there will be much less trouble in securing the material for repairs than where special forms are employed.

W. MCINTOSH,
Superintendent Motive Power.

Norfolk & Western Railway.
Office of Superintendent Motive Power.

I take pleasure in enclosing you copies of letters from Mr. Friese, general foreman, car department, under date of April 1 and November 11, 1902, submitting all of the information which he has been able to collect. You understand, however, that we have not provided any facilities for the repairs of these cars, and the work is being done by ordinary car repairers, with the same tools which we had prior to the adoption of the steel framed cars, which does not therefore represent what may be accomplished if special tools and facilities were provided for doing this work. It is, however, interesting, inasmuch as it represents in a general way the fact that these cars may be maintained with the same class of labor which we employed when only the wooden car was used. In fact, it is my opinion less skilled labor is required, as it only requires one man in charge to do laying-out work and the straightening of parts, riveting, etc., may be done with ordinary laboring forces. We have lately recommended the erection of a structural shop for the manufacture and repairs of this class of equipment provided with punches, shears, furnaces, clamps, traveling cranes, pneumatic machinery, etc., where this work can be prosecuted to better advantage than at the present time.

W. H. LEWIS,
Superintendent Motive Power.

Norfolk & Western Railway Company.

Mr. W. H. Lewis, November 11, 1902.
Superintendent Motive Power.

Up to April 1st of this year we had not gone into keeping accurate record so extensively of this work and we then predicted that the cost of repairs on these cars would range from $175 for badly wrecked cars down to $20 for those slightly damaged. Since that time we have kept records of the cost of this work on a large number of cars and find the above-mentioned figures do not vary greatly from the ones now obtained, in which we find the lowest cost to be $20.36 and the highest $183.48. We did not find any material difference in repairing the class "HF" and class "HG" hoppers, although the class "HF" cars do not have steel side frames, they do have 15-in. side sills and bolsters more complicated and costing for repairs more than the same parts of class "HG" hoppers. We have classified the repairs as follows:

No. 1.—Repairs will include the entire cutting apart of the frame, straightening and re-riveting it, with complete or nearly complete renewal of woodwork, repainting and re-stencilling.

No. 2.—Repairs, cutting apart entire framework, straightening and re-riveting it, with partial renewal of woodwork, repainting and re-stencilling.

No. 3.—Repairs, to include cutting apart, straightening and re-riveting one-half (more or less) of the framework, with renewal of one-half (more or less) of the woodwork, with painting or partial repainting of car.

No. 4.—Repairs will include such cars on which the bent or damaged part of the frame may be straightened and re-riveted without removal. With renewal of rods, rivets, bolts and woodwork that would ordinarily follow slight damage, with partial repainting and stencilling.

Cost of Work Under Above Classification.

No. 1.—Repairs, average, labor $100.23, material $34.55, total $134.78.

No. 2.—Repairs, labor, $77.89, materials $30.46, total $108.35.

No. 3.—Repairs, labor $36.48, material $11.02, total $47.50.

No. 4.—Repairs, average, labor $15.79, material $9.94, total $25.74.

For No. 1—Repairs, labor 74 per cent., material 26 per cent.

For No. 2—Repairs, labor 73 per cent., material 27 per cent.

For No. 3—Repairs, labor 76 per cent., material 24 per cent.

For No. 4—Repairs, labor 61 per cent., material 39 per cent.

For all classes of repairs—Labor 82%, material 18%.

All of the above figures for labor point to the necessity for the erection of a building in which to house necessary tools and equipment to cheapen cost of such repairs. With the large additions now being made to our steel car equipment the present facilities are totally inadequate, irrespective of the additional expense necessary on account of not having proper means to handle this work.

N. L. FRIESE,
General Foreman.

The Christenson Engineering Company, Milwaukee, Wis., state that increased business in Christenson air-brakes and "Ceco" electrical machinery requires a change in their organization which will place their business in the hands of a newly organized concern—the National Electric Company—with purposes, ownership and management the same as before.

THE APPLICATION OF INDIVIDUAL MOTOR DRIVES TO OLD MACHINE TOOLS.

McKEES ROCKS SHOPS.—PITTSBURGH & LAKE ERIE RAILROAD.

BY R. V. WRIGHT, MECHANICAL ENGINEER.

III.

Upon undertaking the drawing up of designs for adapting the individual motor drive to the engine lathes it was decided to use, as far as possible, the arrangement of gearing described in the previous article of this series (pages 165-168 of the May, 1903, issue). Because of the construction of the headstocks of some of the lathes, however, it was found necessary to modify this in a few cases.

On an old type of 25-in. Putnam lathe it was found necessary to arrange the gearing as shown in Fig. 9. The silent chain sprocket, B, and the gear, C, are keyed to an extension hub on the right-hand clutch. Gears H and F run loose on the main spindle, the drive to the back shaft and the other connections being similar in principle to those in the motor drive previously illustrated on page 167.

As shown in Fig. 10 this throws the motor nearer the middle of the headstock than in the arrangement shown in Fig. 4, page 166. It also does away with the special clutch handle bracket shown to the right of the motor bracket in Fig. 7 (page 167); in this case the bracket which supports the motor carries both the clutch handles, as shown in Fig. 10.

Another interesting case is that of a 42-in. Niles triple geared engine lathe (Fig. 12), which required very little changing, only one run of gears and a clutch being added. In this case the belt cone is simply removed and replaced, as indicated in Fig. 11, by a sleeve, which carries, in addition to the pinion 1 and the regular latch plate, a new gear, 3, and the silent chain sprocket, 10. On the back shaft are added a double clutch and a new gear, 4. Gears 1, 2, 5, 6, 7 and 8, are the original ones, while gears 3 and 4 and chain spockets 9 and 10 are new. Gear 2 (Fig. 11) in place of being keyed to the back shaft, runs loose upon it, and the jaw clutch mounted upon it simply fits over the hub of the gear and is keyed to it, as indicated in the detail view at the left of Fig. 12. This special sleeve clutch is shown in detail in Fig. 13.

Upon this type of triple geared lathe the pinion, indicated at 7, on the end of the back shaft, is arranged for meshing with an inside gear at the rear of the face plate; when it is thrown over into mesh, gear 5 is carried along the back shaft with it and out of mesh with gear 6.

With the set of new gears which have been added we will

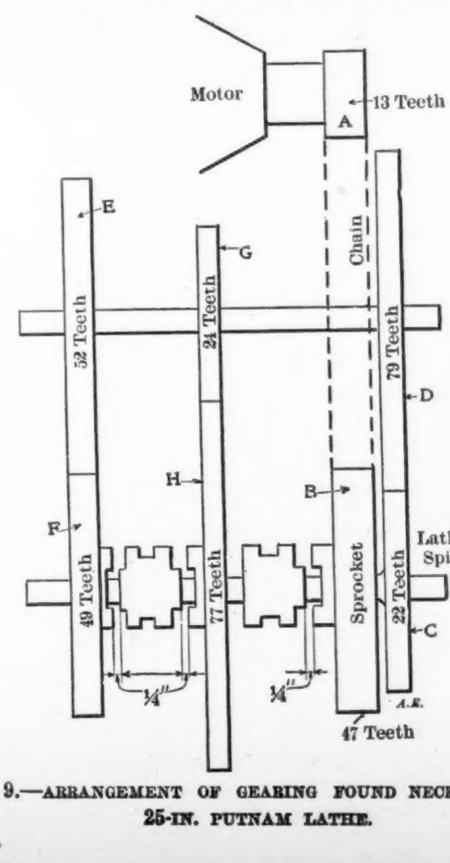


FIG. 9.—ARRANGEMENT OF GEARING FOUND NECESSARY ON A 25-IN. PUTNAM LATHE.

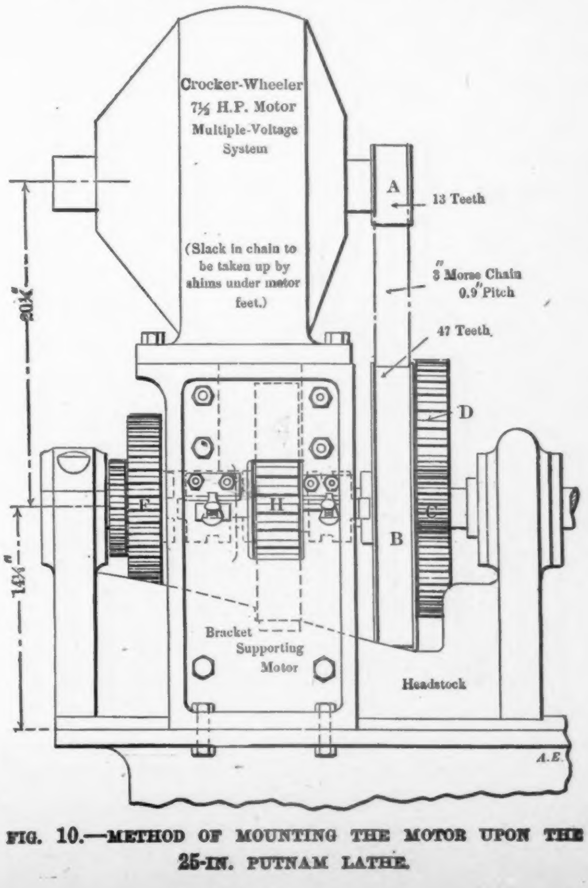


FIG. 10.—METHOD OF MOUNTING THE MOTOR UPON THE 25-IN. PUTNAM LATHE.

have five runs of gearing, or five different speeds, for each motor speed. These reductions will be as follows:

First: $\frac{16}{70}$ (direct, through latch plate);

Second: $\frac{16}{70} \times \frac{52}{119} \times \frac{47}{100}$;

Third: $\frac{16}{70} \times \frac{31}{140} \times \frac{47}{100}$;

Fourth: $\frac{16}{70} \times \frac{52}{119} \times \frac{15}{92}$; and

Fifth: $\frac{16}{70} \times \frac{31}{140} \times \frac{15}{92}$.

The various runs overlap each other, in some cases, but they cover the desired range of speed very nicely.

The lathe spindle speeds, in revolutions per minute, run thus:

	40 volts.	5.7 h.p. 80 volts.	10.3 h.p. 160 volts.	Maximum.
First run	..	55	120	241
Second run	..	..	24.8	49.5
Third run	..	..	12.5	25
Fourth run	..	..	8.6	17
Fifth run	.8	2	4.3	8.7

On this lathe the higher run will not be used much and full power will not be required at these speeds.

In applying the motor, used in this case, the original main spindle and back shaft journal-bearing caps are removed and the cast-iron brackets which carry the angle-iron support for the motor, as shown in Fig. 12, are fitted in their places. The top of the main spindle journal brass is flat, which permits the bracket to be very readily fitted. The bracket required for this support is, of course, of a special design, as is indicated in the detail drawing of it presented in Fig. 14. It will be noted from Fig. 12 that these two special brackets take care of the end bracing also, inasmuch as they are merely tied together at the top by angle bars.

In closing the discussion on the application of the individual motor drive to engine lathes which were originally designed for the belt drive, it might be said, and this refers particularly to the smaller size lathes, that more difficulties had to be overcome in drawing up the designs for changing them than for any other one type of machine tool.

In several cases the design of the headstock was such that it was impossible to put a large enough silent chain sprocket on the main spindle, and the maximum spindle speed, and therefore the speed range, necessarily had to be greater than was actually required. This was not so serious in itself, but

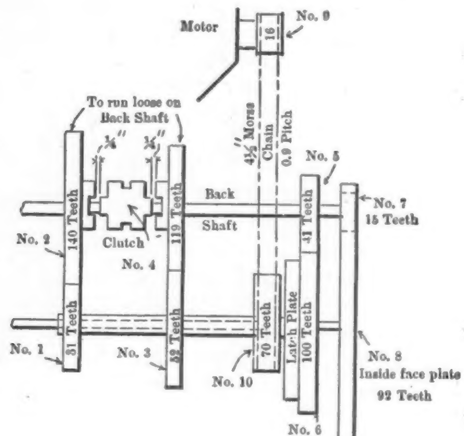


FIG. 11.—ARRANGEMENT OF GEARING UPON A 42-IN. NILES TRIPLE-GEARED LATHE.

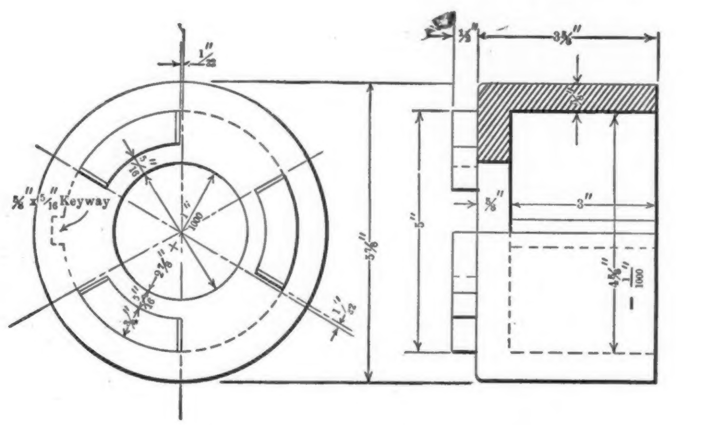


FIG. 13.—SPECIAL SLEEVE CLUTCH KEYED TO THE HUB OF GEAR NO. 2 OF THE 42-IN. NILES LATHE.

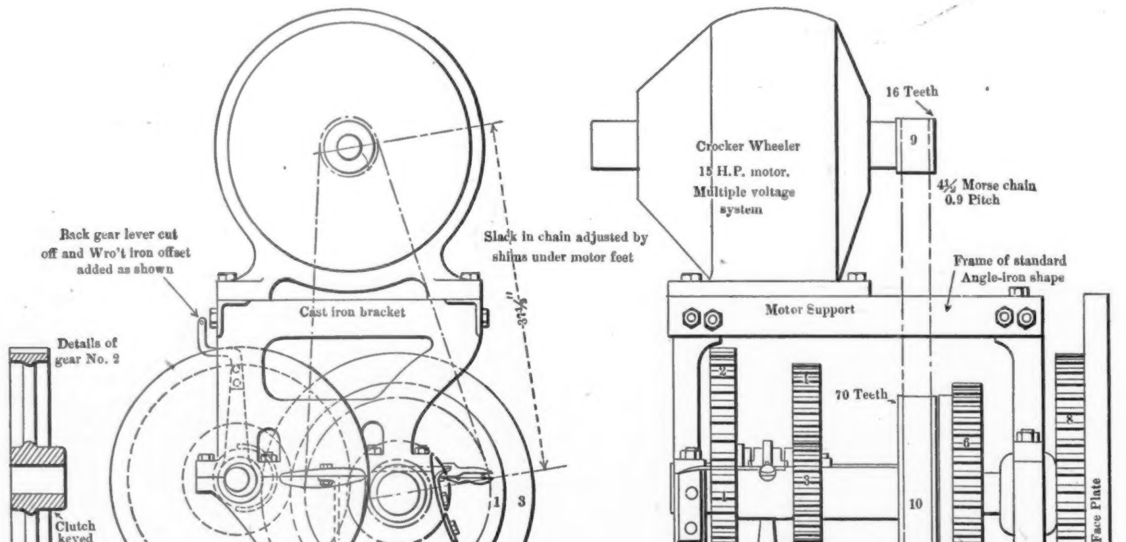


FIG. 12.—METHOD OF MOUNTING THE MOTOR UPON THE 42-IN. NILES TRIPLE-GEARED LATHE.

as a result it was difficult to get the minimum spindle speed desired; this was on account of the fact that a greater reduction had to be made on the two runs of gearing, and that the sizes of the main and back shafts were such that we had to make the cross-section of the metal through the rim of the small pinion, where it was keyed to the shaft, a minimum in order to get the number of teeth small enough for the proper reduction.

In a large machine shop a lathe can, in many cases, be assigned to a particular class of work and, if necessary, the speed range can be more limited than if it was to be used in general work. In one case it was found that the proposed range of speed could not be obtained on account of the construction of the lathe, and it was determined to assign that lathe to a par-

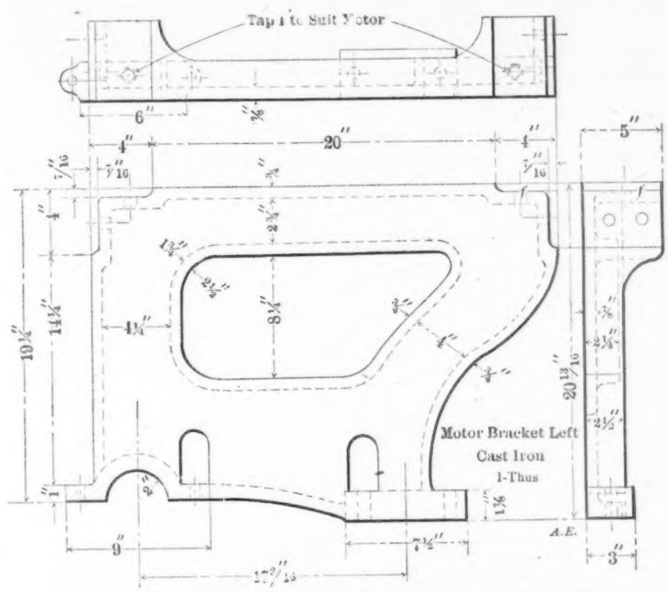


FIG. 14.—DETAILS OF THE SPECIAL BRACKET DESIGNED FOR SUPPORTING THE MOTOR ON THE 42-IN. NILES LATHE.

ticular class of work, the limiting diameters of which were such that the speed limits could be so changed that we could easily arrange for the application of the motor.

In this case the cone will simply be removed and replaced by a sleeve, which will carry a silent chain sprocket and the pinion. The back gear ratio will be properly reduced. The back gear will be thrown in and out in the same manner as before. This is, however, the only case out of the eight lathes to be equipped in which such a radical compromise had to be made.

The limiting sizes of work to be handled on a car axle lathe are such that the motor itself can easily take care of the range of speed required.

The size of work would range from 3¾ ins. in diameter, or a little less, for worn journals for 40,000 lbs. capacity cars to 7⅝ ins., or a little more, the diameter over the rough collar of the axle for a 100,000-lb. capacity car.

Now a cutting speed of 50 ft. per minute over this range of

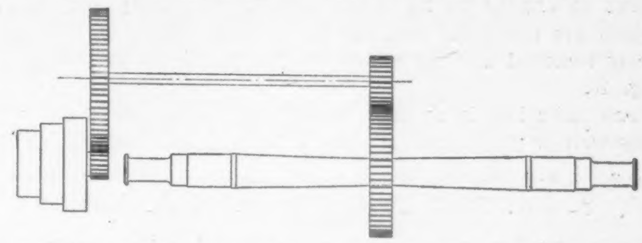


FIG. 15.—ORIGINAL ARRANGEMENT OF GEARING IN THE DRIVE OF A CAR-AXLE LATHE.

diameter would require from 26 to 52 revolutions per minute of the work, or a speed range of 2 to 1. (See Fig. 3, page 166, of the preceding issue.) The material to be cut is soft steel and the constant that should be used in the horse-power formulæ determining the power required to take the cut (see on page 125 of the April, 1903, issue) would probably be about 0.6. For

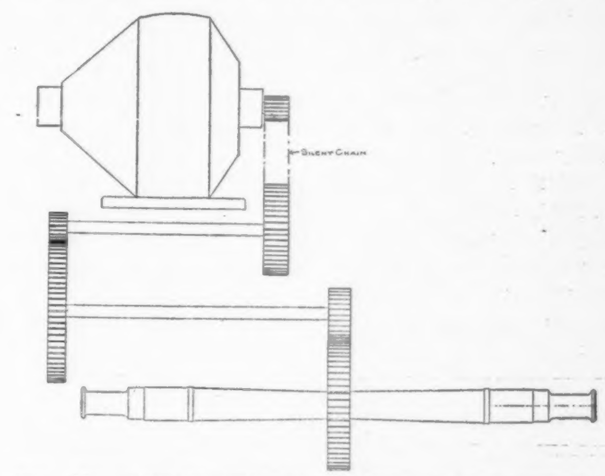


FIG. 16.—DIAGRAM SHOWING CHANGE IN THE DRIVING GEARING OF THE CAR-AXLE LATHE TO ACCOMMODATE MOTOR DRIVE.

a cut 5/16 in. deep taken with 3/32 in. feed the horse-power equals $\frac{3}{32} \times \frac{5}{16} \times 50 \times 12 \times 2 \times .6 = 21$.

By reference to the diagram in Fig. 1 on page 165 of the pre-

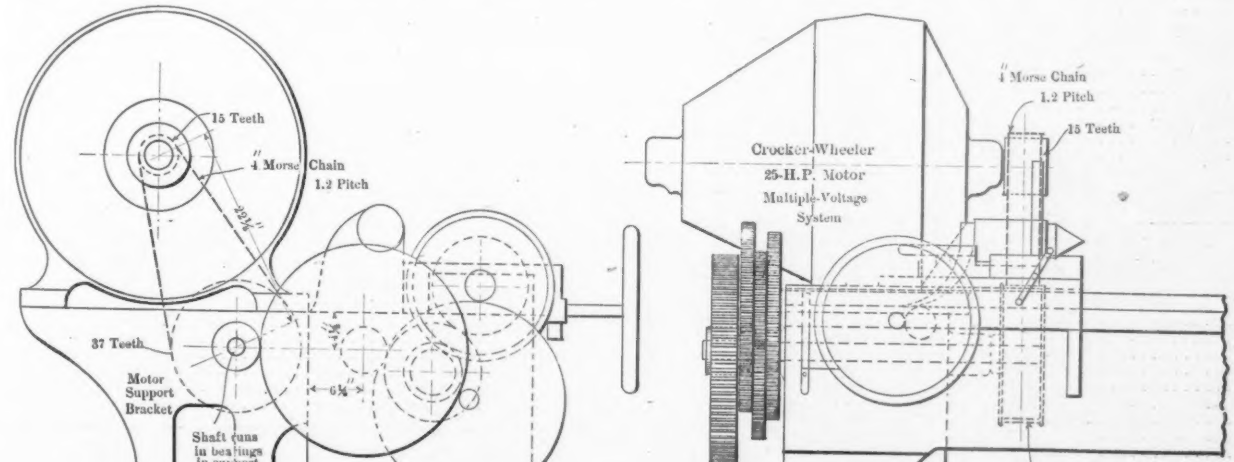


FIG. 17.—ARRANGEMENT OF THE MOTOR SUPPORT BRACKET UPON THE CAR-AXLE LATHE.

ceding issue, it may be seen that the motor, when running at half speed, is exerting 76 per cent. of its rated power. If, at 76 per cent. of full power, 21 h.p. is to be exerted, it may readily be seen that the full power should be about 27.5 h.p. Therefore the tool will require about a 25-h.p. motor.

Fig. 15 shows the arrangement of gearing which was originally applied to the belt-driven axle lathe which we are now about to change to be motor driven. The cone and small pinion are one piece and run on a stud. These will be entirely removed and the motor will be connected as shown in Fig. 16.

The lathe bed is so constructed that the motor could not very well be placed above it and a bracket was designed to fit to the back of the lathe and carry the motor as shown in Fig. 17. The bracket which carries the motor is designed and fitted with bronze bushings to carry the countershaft which has on one end the silent chain sprocket and on the other end the small pinion. The bracket is so near the end of the lathe that it will not interfere with the crane hoist which handles the axles.

(Note:—We are informed by Mr. Wright that in the diagram presented in Fig. 1, page 165 of our May, 1903, issue, the notation in the upper left-hand corner should read "large" and "small" circles, instead of "heavy" and "light." Also in the engraving, Fig. 7, on page 167, handle A should be marked B, and vice versa. We regret these errors.—Ed.)

POWER TEST OF GROUP DRIVE MOTORS.

Records of Power Required for the Group Drives at the Roanoke Shops.

NORFOLK & WESTERN RAILWAY.

Through the courtesy of Mr. W. H. Lewis, superintendent of motive power, we are enabled to present the following records of an elaborate series of tests recently made at the Roanoke shops to determine the power required by the various group drive motors for machine driving. As will be recalled, the Roanoke shops were equipped for electric driving about a year ago, the two-wire, 220-volt direct-current distribution system being used and the machines being driven in groups by constant-speed motors to the exclusion of individual driving. An account of this installation was presented by Mr. C. A. Seley in a paper before the 1902 convention of the Master Mechanics' Association. (See abstract on page 230 of our July, 1902, issue.)

Graphical records are presented of tests made upon fifteen of the group-drive motors. The machines connected in each group are given in the accompanying tool list. The following is quoted from the report of Mr. Quinn, electrician at the shops:

"Herewith are attached graphical results of the motor tests made at the Roanoke shop. These data are from consecutive readings taken during a five hour test and show the performance of the motors during the heaviest load that we would expect to occur during the day. Each test record shows the power consumed with the motor running light, the power consumed with the motor and shafting running light, and the power required for the motor, shafting and machines, all together.

"By taking the readings from the middle of tests, we were sure that the motors were thoroughly heated and the internal losses were at a maximum, and results show what could be expected in every-day practice, and not results from short, intermittent tests of a few minutes with machines operating for the special benefit of the test to be made. No special effort was made to load up machines, or in any way deviate from the every-day practice in operation of the machines in the shop, as the results desired are for future reference, and are to give a broad idea of what might be expected from motors of different sizes when used for group driving, and also to determine to what extent, and for what length of time, we might overload a motor and still expect it to continue in service.

"Some of the results shown are very remarkable, especially that of the test of group No. 9. I believe that these results,

GROUP TOOL LIST.

TESTS OF GROUP MOTORS AT ROANOKE SHOPS.

MACHINE SHOP.

GROUP NO. 1—20-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 20 H.P.
Minimum power required = 12.6 H.P.
Average power required = 16 H.P.

Machines.	Size.	Makers.
Quartering machine	No. 2	N. Y. Steam Eng. Co.
Lathe	18 ins. x 16 ft.	Schenck.
Emery wheel		
Driving-wheel lathe	80-in. plate	Sellers.
Milling machine	Keyways in axle	Newton.
Pipe cutter		D. Saunderson & Son.
Slotter	12-in. stroke	Niles.
Slotter	16-in. stroke	Niles.
Slotter	6-in. stroke	Newton.
Vertical boring mach.	84 ins. diameter	Niles.
Vertical boring mach.	84 ins. diameter	Niles.
Keyway milling mach.	42 ins. long	Bement & Son.
Cylinder planer	60 x 60 ins	Sellers.
Lathe	14 ins.	Bement & Son.
Cylinder borer		Niles.
Radial drill press		Niles.
Lathe	16 ins. x 13 ft.	Sellers.
Lathe	14 ins. x 12 ft. 6 ins. extension	Harrington.
Lathe	8 ins. x 7 ft.	Blair.
Hydraulic wheel press		

GROUP NO. 2.—20-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 18.9 H.P.
Minimum power required = 10.6 H.P.
Average power required = 14.4 H.P.

Lathe	8 ins. x 7 ft.	Blair.
Lathe	8 ins. x 7 ft.	Blair.
Lathe	8 ins. x 7 ft.	Blair.
Lathe	8 ins. x 7 ft.	Blair.
Lathe	7 ins. x 7 ft.	Grant & Bogert.
Frame slotter	3 heads	
Lathe	8 ins. x 6 ft., brass	Lodge & Davis.
Lathe	10 ins. x 10 ft.	
Lathe	8 ins.	R. K. LeBlond.
Drill Press	50 ins.	Niles.
Lathe	8 ins.	R. K. LeBlond.
Lathe	Brass	Cooper, Jones & Cabu.
Planer	36 x 36	Sellers.
Lathe	7 ins.	Grant & Bogert.
Lathe	Brass	Cooper, Jones & Cabu.
Lathe	Brass	Springfield Mch. T. Co.
Lathe	Brass	Springfield Mch. T. Co.
Lathe	Brass	Grant & Bogert.
Planer	48 x 48	Sellers.

GROUP NO. 3.—35-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 37.6 H.P.
Minimum power required = 12 H.P.
Average power required = 17 H.P.

Lathe	Brass	Am. Tool Mach. Co.
Lathe	8 ins., brass	Manning, M. & Moore.
Stud lathe		Niles.
Emery wheel		
Lathe	12 ins.	Flather & Co.
Stud lathe		Jones & Lamson.
Stud lathe		Smith & Courtney.
Lathe turret		Niles.
Lathe	8 ins.	Lodge & Davis.
Planer	36 x 36 ins.	Sellers.
Lathe	10 ins.	Flather & Co.
Grinding lathe		Whitworth.
Drill press		
Drill press		
Lathe	8 ins.	Manning, M. & Moore.
Flue rattler		
Hydraulic press	Small, for rod brasses	
Polishing wheel		

GROUP NO. 4.—15-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 19.4 H.P.
Minimum power required = 3.4 H.P.
Average power required = 10.2 H.P.

Gang drill	6-spindle	Bement Miles.
Rod drill		Pond Machine Co.
Rod drill		Niles.
Drill press		

GROUP NO. 5.—20-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 35.4 H.P.
Minimum power required = 6.3 H.P.
Average power required = 14.7 H.P.

Double-head axle lathe		Niles.
Double-head axle lathe		Niles.
Double-head axle lathe		Niles.
Double-head axle lathe		Niles.
Double-head axle lathe		Niles.
Emery wheel		Niles.

GROUP NO. 6.—20-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 28.9 H.P.
Minimum power required = 4.7 H.P.
Average power required = 11.2 H.P.

Wheel grinder		
Wheel borer	Car Wheels	Niles.
Wheel borer	Car Wheels	Niles.
Wheel borer	Car Wheels	Niles.
Wheel borer	Car Wheels	Bement Miles.
Hydraulic press	Car Wheels	Niles.

when the first cost, cost of maintenance and weight of metal removed per dollar invested in driving machinery is considered, will compare favorably with other methods of electrical driving. This is to a certain extent brought about by having the piecework system in use in these shops, which makes the cost of turning out a piece of work a fixed quantity. The variable is therefore found in the cost of driving the machine, and, while this is a very small percentage as compared with the wages of the machinists, still in a shop of this size I believe it will amount to quite an item, especially when the interest on original investment is taken into consideration.

"The majority of machines in this shop are each doing a certain class of work, which calls for very few speed changes, and by having the piecework system in use, we may conclude that each machine is operated at its most economical speed, and that individual driving would thus not increase the output to any marked extent.

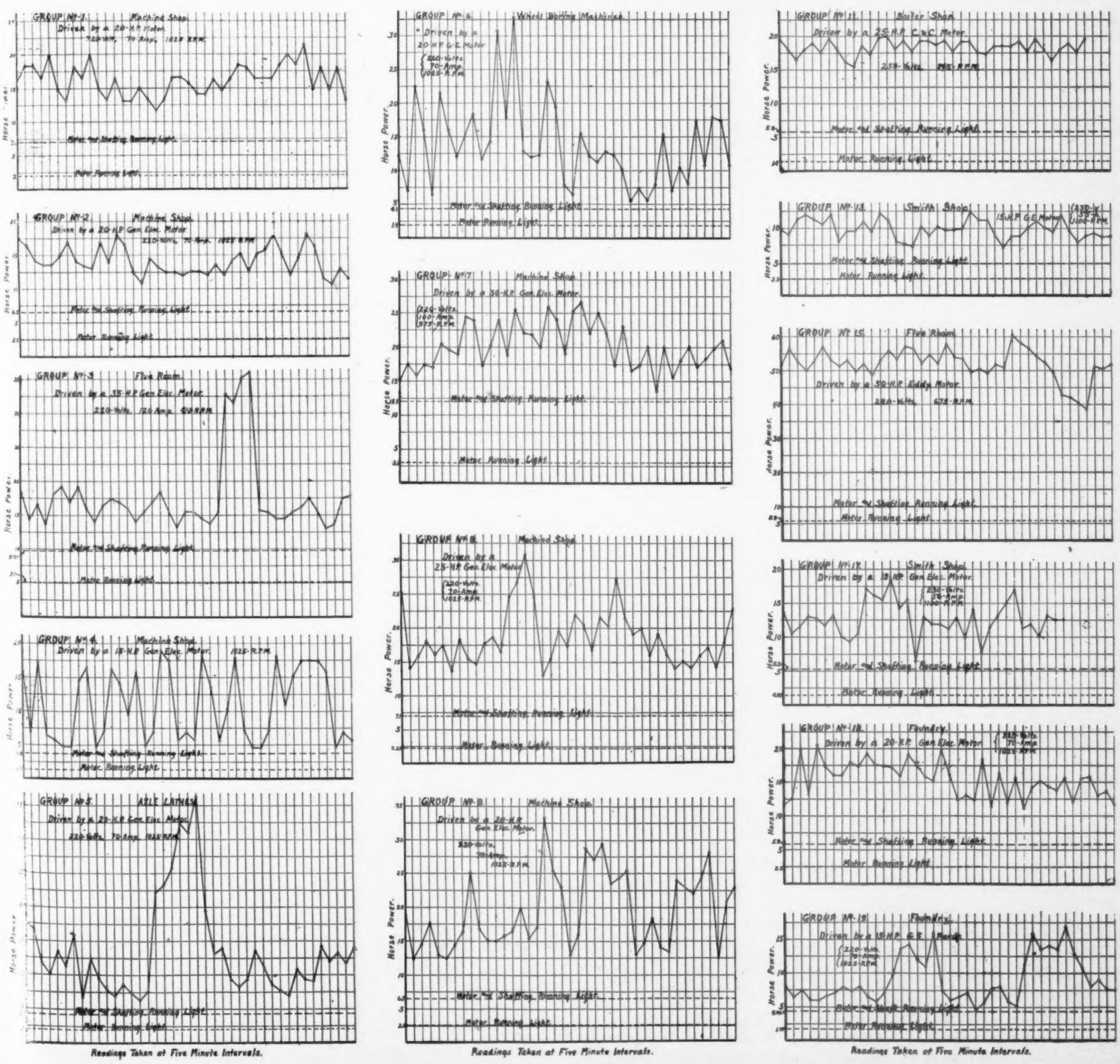
"With the attached sheets you will find the power used by the motor running alone, disconnected, represented by the lowest dotted line, and that for the motor and the line shaft only (with all machines idle) represented by the upper dotted line. From these two lines we can readily see what percentage of power is taken up by shafting and belting,

GROUP NO. 7.—30-H.P. GENERAL ELECTRIC MOTOR.

Maximum power required = 27.7 H.P.
Minimum power required = 9.2 H.P.
Average power required = 19 H.P.

Hor. D. B. borer		Bement & Son.
Vert. milling machine	36 ins. diameter	Hilles & Jones.
Shaper, double-head	12-in. stroke	Bement & Son.
Vert. D. B. borer		Niles.
Planer	32 x 32 ins.	Niles.
Hor. milling machine		Bement, Miles & Co.
3 grindstones		
1 polishing wheel		
1 emery wheel		
Guide grinder		Kendall & Gentry.
(TOOL ROOM.)		
Lathe	8 ins.	Blair.
Lathe	7 ins.	Grant & Bogert.
Lathe	7 ins., hand feed	
Shaper	8-in. stroke	Bement & Son.
Univ. milling machine		Brown & Sharpe.
Single milling mach.		Pratt & Whitney.
Planer	16 x 18 x 30 ins.	Pratt & Whitney.
Hack saw		Millers Falls Co.
Drill press		Harrington & Son.
2 emery wheels (double)		
Twist drill grinder		L. S. Heald & Son.

(Owing to lack of space the remainder of this tool list will appear in the succeeding issue.—ED.)



DIAGRAMS SHOWING VARIATIONS IN POWER DEMANDED BY THE VARIOUS GROUP MOTORS.

POWER TESTS OF GROUP-DRIVE MOTORS—ROANOKE SHOPS, NORFOLK & WESTERN RAILWAY.

and approximately that which goes into the tools driven."

"Test No. 3 is taken from the motor that drives the flue rattler, and the peak represents the load with the rattler on. The smaller machines being easily driven from this shaft, they were kept belted to it, and the installing of an extra motor to drive them thus avoided. From this sheet you may also see approximately the length of time necessary to rattle a certain set of flues.

"Record No. 5 shows a very high peak in the middle of the curve, which is the result of four lathes starting on new axles at the same time. You may notice how the curve dips just before it starts up the peak; this is due to the finishing cuts and polishing of the axles. I might add that this curve represents the most severe test that could be given this motor, and would probably not occur more than once in a week, as it was brought about by changing from one class of axles to another. From the general appearance of the curve (neglecting the peak) we might infer that a 15-h.p. motor would more nearly fit these conditions; but I have tried a 15-h.p. motor and it would not give the desired results. Sparking and heating of the commutator was too frequent to permit it driving this group of machines.

"The 20-h.p. motor for group No. 6 was put in because the fourth boring mill is not in use at all times and the curve shown represents three machines with the wheel presses, and up to the present time this motor has carried the fourth machine without any trouble. The very high load shown by record No. 9 is due to the walking crane, and is of a temporary nature.

"The 25-h.p. motor indicated in record No. 11 is a second-hand machine, already owned by the railway company, and I used it at this point on account of the limited space that I had, and also to get the benefit of the enclosed type of motor, which was very necessary at this point, on account of the surrounding machines, and the shavings flying from them.

"The 15-h.p. motor indicated in record No. 13 shows the effect of external heating, due to the proximity of the bolt furnaces and the piling of heated, newly-made bolts in the neighborhood of the machine. This motor is operating at only approximately two-thirds load, but a 10-h.p. machine would not give satisfactory results if put in its place, owing to this excessive heating. I have omitted record No. 16, as the results from the test on this group was of very little practical use, the group of machines being very small and the work of a varying nature.

"I might add, in conclusion, that these motors have all been loaded so that the best results with regard to good running and maximum load might be obtained—neither being sacrificed for the other. The motors have been running for six months with the loads herewith shown, and nothing has developed that would indicate the necessity of a change in any of the groups. This does not include the installing of new machines, which, in the future, may make it necessary to make additions or changes in some of the groups where this would occur."

We are indebted to Mr. J. A. Pilcher, mechanical engineer of the Norfolk & Western, for these records, the tests having been carried out by Mr. Quinn, electrician of the Roanoke shops.

THE PROPORTIONS OF MODERN LOCOMOTIVES.

LAWFORD H. FRY.

The accompanying tables show the results of an investigation of the main proportions of over two hundred modern locomotives of all classes. This analysis was carried out with the idea of studying the proportions given to modern locomotives by their designers. By collecting a sufficient number of examples and properly grouping and averaging them figures have been obtained which give definite information regarding current American practice. The figures on which the present tables are based cover practically all of the important locomotive designs which have been described in the technical papers in the last three years. In nearly every class of engine examined the examples are sufficiently numerous to give average results not largely influenced by any special design. The examination covers those principal ratios, or factors of design, which enable proper comparisons to be made between the fundamental proportions of the various engines, viz.:

Factor of Adhesion.—Measuring the proportion of weight on driving wheels to maximum cylinder tractive effort.

Factor of Steaming Capacity.—Measuring the proportion of cylinder power to boiler power.

Factor of Efficiency of Design.—Measuring the proportion of total weight to heating surface obtained.

Table 1 shows the average values of these factors as determined for the locomotives of each type and class. The engines in many of the classes have been subdivided into groups, according to their weight, and the average factors determined for each group, so as to show the influence of the weight of the engines on the value of the factors. The results of this show several points in favor of the heavy engines.

In column 1, of table 1, is given the type of the locomotive and in column 2 is given the class. By "type" is to be understood the wheel arrangement, as Atlantic-type, American-type, etc., and by "class" is to be understood the style of cylinders, whether single expansion, or two, or four-cylinder compound. The tandem and Vauclain compounds have not been separated, as the difference between these does not affect any fundamental principal of design. In column 3 are given the limits of weight between which the locomotives in each group are contained. The aim has been to give each group a range of 10,000 lbs., but the grouping is of course dependent on the number and weight of the locomotives in each class, and in several cases the number of engines in the class has not been sufficient to justify a subdivision. Column 4 gives the number of locomotives in each group. In addition to taking the average of the factors for each group, averages have been struck for each class as a whole, and these figures are given in heavy type below the figures for the groups. The last four columns contain the factors forming the chief object of the investigation.

Column 5, Weight on drivers ÷ tractive effort.

Column 6, Tractive effort ÷ heating surface.

Column 7, Tractive effort × driving wheel diameter ÷ heating surface.

Column 8, Total weight ÷ heating surface.

For reference and comparison the average values of the factors have been collected into separate tables for each factor.

Factor of Adhesion. Table 2.—In this table the average factors from column 5, table 1, are collected according to type and class. It will be seen that the single expansion factors are arranged in ascending order of value. The way in which the types arrange themselves is interesting. The standard types take the following order:

Consolidation, 4.03; American, 4.17; Atlantic, 4.33; Mogul, 4.50; Ten-wheeler, 4.66.

The majority of these are lower than are recommended by the Master Mechanics' Association, and it would seem that the Consolidation and American-type engines are designed to utilize their full adhesion when running with less than full stroke cut-off. The position of the Moguls appears to need some explanation, as there is no obvious reason why they should not have practically the same factor as the Consolidations. An explanation of the value of the factor for the Ten-wheelers is obtained by considering them as American-type engines with an additional pair of driving wheels. The limit of weight with two pairs of drivers having been reached, a further increase in weight requires a third pair of drivers, and, in adding these, more weight is added than is required for the increase in tractive power. In other words, in changing from the American to the Ten-wheeled type, structural considerations render it necessary to make the increase in weight on driving wheels proportionately greater than the increase in cylinder tractive effort. A similar consideration of the Prairie-type as an enlarged Atlantic-type explains the high factor of adhesion of the Prairie-type.

It will be noticed that the four-cylinder compounds show approximately 10 per cent. higher factors than the single expansion engines of the same class. This is of course due to the fact that the compounds are designed to work with a longer cut-off, and on starting they can, by admitting live steam to the low pressure cylinders, develop for a short time a greater tractive effort than that counted on in the tables. In calculating the tractive effort for the tables the mean effective pressure has been taken at 85 per cent. of the boiler pressure for the single expansion engines. For the four-cylinder compounds the high pressure mean effective is taken as two-thirds and the low pressure as one-quarter of the boiler pressure. For the two-cylinder compounds the work is assumed to be equally divided in the two cylinders, the mean effective in the high-pressure cylinder being taken as two-thirds the boiler pressure.

Factor of Steaming Capacity. Table 3.—This table contains the average values from column 7 of table 1. The value of the ratio given in column 6 (tractive effort to heating surface) is obviously, for any given locomotive, a measure of the proportion of the cylinder power to the boiler power, but as the tractive effort is inversely proportional to the driving-wheel diameter, the ratio is dependent on the driving-wheel diameter and is therefore not generally suitable for comparing the steaming capacities of locomotives. By multiplying by the driving wheel diameter one obtains the factor given in column 7, table 1, which is free from this objection and which can be shown by theoretical considerations to be a proper measure of the steaming capacity of any locomotive. (See AMERICAN ENGINEER, October, 1902, and February, 1903.) It is found, theoretically, that for high speed service the steaming capacity factor should have a low value and that a high value factor indicates that the engine is suitable for slow speed service. This is well confirmed by the figures obtained from actual practice and given in table 3. This table gives a practical value to the steaming capacity factor, for it puts one in the position of being able to say at once for any engine how the relation between heating surface and cylinders stands in regard to current practice.

Factor of Efficiency of Design.—The collected results from column 8, of table 1, are shown in table 4. The average weight per square foot of heating surface is given for each class and then the figures for all the classes of each type are averaged together. It will be seen that the high speed types are the lightest per unit of heating surface and that there is a gradual increase in weight towards the slower freight engines. This factor shows the economy or otherwise with which the designer has arranged his material and deserves considerable attention. Any unnecessary weight has to be paid for in the first instance and has ever afterwards to be hauled about as dead weight, and it is therefore obviously desirable to keep the total weight as low as is consistent with strength and satisfactory design. The average figures do not show any marked variations, but the individual figures from which the tables are compiled show a wide range of weights per unit of heating surface, going from 49.4 lbs. per square foot of heating surface up to over 80 lbs. per square foot.

TABLE 1. AVERAGE VALUES OF FACTORS OF COMPARISON.

Type.	Class.	Weight Limits.	Number of locomotives.	Weight on drivers / Tractive effort	Tractive effort / Heating surface	Tract. eff. × driv. dia. / Heating surface	Total weight / Heating surface
Pacific (4-6-2)	Sing. exp..	**219,000–173,000**	**4**	**4.39**	**8.61**	**622**	**55.9**
Prairie (2-6-2)	do	**203,600–140.000**	**7**	**4.94**	**8.56**	**584**	**58.0**
do	4-cyl. comp.	**209,900–176,000**	**4**	**4.61**	**8.94**	**609**	**58.0**
Atlantic (4-4-2)	Sing. exp..	191,000—180,000	3	4.11	7.65	631	62.4
do	do	180,000—170,000	6	3.91	7.99	619	56.5
do	do	170,000—160,000	3	4.01	8.38	646	59.1
do	do	160,000—150,000	6	4.11	8.36	635	61.3
do	do	141.000—136,200	4	4.47	9.17	689	64.2
do	do	**191,000–136·200**	**22**	**4.33**	**8.31**	**641**	**60.4**
do	4-cyl. comp.	183,000—180,000	2	4.79	6.63	557	58.9
do	do	180,000—160,000	4	5.18	6.54	551	64.3
do	do	150,000—132.700	5	4.34	7.59	590	65.4
do	do	**183,100–132,700**	**11**	**4.73**	**7.03**	**561**	**63 8**
American (4-4-0)	Sing. exp..	**146,400–104,800**	**11**	**4.17**	**9.99**	**707**	**63.0**
Ten-wheel (4-6-0)	do	179,000—170,000	7	4.94	9.46	716	63.8
do	do	170,000—160,000	5	4.64	11.27	762	67.6
do	do	160,000—150,000	11	4.47	11.47	748	65.9
do	do	150.000—128.200	7	4.64	10.91	760	66.6
do	do	**179 000–128 200**	**30**	**4.66**	**10.94**	**746**	**65.8**
do	4-cyl. comp.	191,800—180,000	5	4.92	9.90	692	65.6
do	do	180,000—170,000	4	4.90	9.79	652	64.3
do	do	160,000—138,700	4	5.11	9.57	684	66.2
do	do	**191 800–138 700**	**13**	**4 97**	**9.76**	**678**	**65.3**
do	2-cyl. comp.	175,500—150,000	5	4.68	10.05	670	63.5
do	do	141,000—105,000	4	4.73	12.11	724	74.1
do	do	**175,500–105,000**	**9**	**4.70**	**10.97**	**694**	**68.2**
Conslidtn. (2-8-0)	Sing. exp..	250.300—200,000	6	3.98	14.57	827	63.6
do	do	200,000—190,000	5	3.91	14.91	792	63.6
do	do	190.000—180,000	11	4.20	13.95	781	65.4
do	do	180,000—170.000	7	3.95	14.35	793	63.0
do	do	170,000—160.000	8	3.94	14.91	841	64.9
do	do	160,000—150,000	7	4.05	15.93	868	70.9
do	do	141.900—121.700	3	4.03	15.06	791	68.9
do	do	**250 300–121 700**	**47**	**4.03**	**14.72**	**815**	**65.7**
do	4-cyl. comp.	225.100—200,000	9	4.24	13.01	742	62.2
do	do	200.000—190,000	2	4.25	13.12	790	62.3
do	do	190,000—180,000	8	4.31	14.91	839	73.3
do	do	180,000—135.800	6	4.37	15.22	835	75.1
do	do	225,100—135.800	25	4.30	14.15	798	68.9
do	2-cyl. comp.	**200,000–144,000**	**10**	**4.01**	**14.64**	**829**	**66.4**
Mogul (2-6-0)	Sing. exp..	169.000—160,000	5	4.50	12.54	766	60.5
do	do	155 000—126,000	6	4.49	13.78	858	71.6
do	do	**169,000–126,000**	**11**	**4.50**	**13.21**	**806**	**66.5**
do	4-cyl. comp.	**168,900–135,000**	**3**	**4.71**	**13.09**	**791**	**71.8**
Mastodon	Sing exp..	**221,500–172,000**	**6**	**3.86**	**14.30**	**789**	**68.0**
do	2-cyl comp.	**193,000–182,200**	**5**	**4.02**	**13.99**	**767**	**70.9**

TABLE 2. FACTOR OF ADHESION.

Type.		Single expansion		4-Cylinder compound.		2-Cylinder compound.	
		No. of Locos.	Factor of adhesion.	No. of Locos.	Factor of adhesion.	No. of Locos.	Factor of adhesion.
Mastodon	(4-8-0)......	6	3.86	..	...	5	4.02
Consolidation	(2-8-0)......	47	4.03	25	4.30	10	4.01
American	(4-4-0)......	11	4.17	..	...	..	...
Atlantic	(4-4-2)......	22	4.33	11	4.73	..	...
Pacific	(4-6-2)......	4	4.39	..	...	..	...
Mogul	(2-6-0)......	11	4.50	3	4.71	..	...
Ten-wheel	(4-6-0)......	30	4.66	13	4.97	9	4.70
Prairie	(2-6-2)......	7	4.94	4	4.61	..	...

TABLE 3. FACTOR OF STEAMING CAPACITY.

Type.		Single expansion.		4-Cylinder compound.		2-Cylinder Compound.	
		No. of Locos.	Steaming factor.	No. of Locos.	Steaming factor.	No. of Locos.	Steaming factor.
Prairie	(2-6-2)........	7	584	4	609	..	...
Pacific	(4-6-2)........	4	622	..	...	..	...
Atlantic	(4-4-2)........	22	641	11	561	..	...
American	(4-4-0)........	11	707	..	...	..	...
Ten-wheel	(4-6-0)........	30	746	13	678	9	694
Mastodon	(4-8-0)........	6	789	..	...	5	767
Mogul	(2-8-0)........	11	806	3	791	..	...
Consolidation	(2-8-0)........	47	815	25	798	10	829

TABLE 4. FACTOR OF EFFICIENCY OF DESIGN.

Type of locomotive.		Number of locomotives of each class				Average total weight in lbs. per sq. ft. of heating surface.	
		Single expansion.	4-Cylinder compound.	2-Cylinder compound.	All classes.	Average for class.	Average for type.
Pacific	(4-6-2)......	4	..	..	4	55.9	55.9
Prairie	(2-6-2)......	7	..	..	..	58.0	...
		..	4	..	..	58.0	...
		..	..	..	11	...	58.0
Atlantic	(4-4-2)......	22	..	..	..	60.4	...
		..	11	..	..	63.8	...
		..	..	..	33	...	61.5
American	(4-4-0)......	11	..	..	11	63.0	63.0
		..	13	..	..	65.3	...
Ten-wheel	(4-6-0)......	30	..	..	..	65.8	...
		..	..	9	..	68.2	...
		..	..	..	52	...	66.1
Consolidation	(2-8-0)......	47	..	..	..	65.7	...
		..	25	..	..	68.9	...
		..	..	10	..	66.4	...
		..	..	..	82	...	66.8
Mogul	(2-6-0)......	11	..	..	..	66.5	...
		..	3	..	..	71.8	...
		..	..	..	14	...	67.6
Mastodon	(4-8-0)......	6	..	..	..	68.0	...
		..	..	5	..	70.6	...
		..	..	..	11	...	69.2

"Resorts and Tours, 1903," is the title of the valuable little brochure published by the Boston & Maine Railroad passenger department, Boston. It contains a list of the resorts and hotels reached by the Boston & Maine Railroad and its connections, giving additional information in regard to the hotel rates and accommodations, the round trip summer excursion rates from Boston, Worcester and Springfield, Mass. The book is free and will be mailed upon receipt of address.

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CONTENTS.

RATIONAL DESIGN OF LOCOMOTIVE BOILERS.

Under this heading Mr. D. Van Alstyne presented in our June number of last year a strong argument for more space for circulation in locomotive boilers. In this issue Mr. John Player, of the Brooks Works of the American Locomotive Company, adds a powerful impetus to the tendency to sacrifice in the amount of heating surface which may be shown on paper in order to increase the effectiveness of the real heating surface, and this comes from a man whose opinion carries the weight of wide experience and who is known as a designer of successful locomotives. In this issue is illustrated the boiler of a locomotive having a 5-in. mud ring and an account of tests appears which seems to conclusively prove that a layer of steam ¾ in. thick does lie against the sheets of fireboxes when working hard. Mr. Player also makes an important suggestion with reference to the delivery of water from injectors. Two large injectors delivering in the line of circulation at the bottom of the boiler and toward the throat could not fail to help out the firebox sheets and tubes, and we believe the delivery should be at the throat itself. The reader is advised to give most careful consideration to the words of Mr. Player.

CARNEGIE'S GIFT TO ENGINEERS.

A gift of a million dollars to the national engineering societies for a building in which to provide a center for engineers is the latest beneficence of Andrew Carnegie. It has been reported that a union of the societies was contemplated, but this is not true and it is not desirable. Great good may be accomplished by bringing together the various organizations representing mechanical, civil, electrical, mining and marine engineering in one well-appointed building wherein they may co-operate, meet and perhaps concentrate their independent libraries, thus forming a rendezvous for many professional men who are engaged upon various kinds of special work with much of common interest. The importance of this association of the societies, from a social standpoint, is very great, and the possibilities of advantage to all from this sensible concentration are so obvious as to lead to the hope that nothing will prevent a complete and broadminded acceptance of this extraordinary opportunity to accomplish that which has long been desired but has seemed to be impossible. The most distinguished patron of engineering could not have done anything wiser or more far-reaching in the interests of this profession.

STEEL FRAME BOX CARS.

Of all types of cars to which steel framing has been applied the box car presents the most difficult problem and one which has generally been met with a compromise rather than a definite, clean-cut solution. The design by Mr. C. A. Seley which is described by him in this issue meets the problem fairly and is therefore worthy of most careful attention. This is not a steel underframe surmounted by a box structure having its own skeleton of steel and merely fastened to the underframe. It is a complete steel structure wherein the side frames of the box form an important element in the structure and do their part in carrying the load. This is a steel-frame box car in fact as well as name. This design is based upon successful cars of similar construction which are now running on the Norfolk & Western, and, as pointed out by the designer, the new plan is an improvement upon the older one. It may be remarked, incidentally, that Mr. Seley seems to have met the car-roof problem by preventing the weaving, or racking, of the upper structure. The writer is of the opinion that a careful examination of Mr. Seley's drawings will lead many to change their minds entirely with respect to the construction of steel-frame cars of this type.

WEAKNESSES IN M. C. B. KNUCKLES.

Whenever Mr. G. W. Rhodes says or writes anything on a mechanical subject connected with his life work it is sure to be important. The attention of railroad officers is directed to his strenuous appeal for the relegation of link slots and pin holes which he presents in his article on page 243, this issue. When he says, "There is nothing more serious or disastrous on a railroad than a break-in-two with a freight train," he voices the feelings of all who understand train operation. It is to be hoped that this forcible statement of the situation will result in the banishment of this fault from the M. C. B. knuckle and that it will be done at Saratoga at the coming convention.

"AMERICAN ENGINEER" TESTS.

Professor Goss has completed the series of tests on stacks, and in this issue his conclusions appear. These are printed now in order to place the results before the readers at the time of the Master Mechanics' convention, and the remaining portion of the record will be presented later.

At the 1902 convention of the Master Mechanics' Association, in accordance with a suggestion by President Waitt, the executive committee was instructed to assist in the tests, and a special committee was appointed to co-operate with THE AMERICAN ENGINEER in the work. This committee met a representative of this journal in October last and arranged for tests to be made on several railroads, to check the conclusions of the report with results obtained in service. This committee will report at the approaching convention.

The next step will be to take up the investigation of the front-end problem in large locomotives.

THE OPPORTUNITY OF THE MASTER MECHANICS' ASSOCIATION.

Those who are watching the career of the American Railway Master Mechanics' Association with the greatest interest believe that it is now facing an opportunity which is in many ways the most important which has ever come before it.

In his presidential address last year Mr. Waitt directed attention to the desirability of conducting tests under the direction and financial responsibility of the association, through which many questions relating to the efficiency of operation of locomotives may be studied; and this is the opportunity to which the attention of railroad officers should be directed.

At times most excellent and valuable investigations have been made by the association, of which the exhaust nozzle tests of 1896 are a conspicuous example. With the growth of the locomotive and the advances of the present time in methods of designing and maintaining, it is specially necessary that various very important questions should be carefully investigated and reported upon by experts working under the direction of those who are responsible for locomotive operation, and this cannot be properly done except by this organization or under its direction and control. The work must be controlled and directed by those who know the needs and who can eliminate all question of personal opinion or advantage.

Perhaps THE AMERICAN ENGINEER Tests have given an impetus to the idea of the necessities of a thorough, systematic study and investigation of features of locomotive design, but whether or not this is the cause at the present time, two committees will report this year upon the subject of tests and the association will soon consider ways and means for providing for tests under the auspices of the association.

The reason why this offers a great opportunity to increase the usefulness of the association is that it presents a method of uplifting the whole mechanical department to a higher plane of usefulness by furnishing information which should control and direct the efforts of locomotive men in an intelligent way which may be immediately reflected in the commercial results of operation. For this reason the railroads can well afford to give generous financial support.

The railway clubs are doing in an admirable way much of the work formerly falling to this association, and it seems desirable in every way to give a large proportion of attention to investigation and to other work which none but a national organization can do.

The strength of the Master Car Builders' Association lies in the fact of its representative membership in matters connected with car interchange. The Master Mechanics' Association would be wise to obtain the advantage of representation of the railroads which would necessarily follow the inauguration of the policy under discussion.

Many new problems are arising, and these all involve commercial questions of large investments. Some of them may be mentioned as general lines for investigation. For example, we have the big engine, compounding, valve gears, superheating, water purification, power house practice, motor driving of machine tools, cuts, feeds and speeds of machine tools. All these are important questions which involve large expenditures which should be administered with the utmost possible intelligence rather than by the cut and try policy which must necessarily prevail in the absence of definite knowledge of cause and effect which well considered tests would disclose.

FLYWHEELS ON PLANER DRIVES.

The recent criticism by the *American Machinist* of the article by Mr. J. C. Steen, entitled: "Driving Planers," appearing in our May issue, gives evidence of a failure to carefully read the article. The article was, *in no sense* a record of a test of a planer drive, being nowhere so stated. It was written to describe, briefly, a condition of planer driving that had existed for several years. The scope of the article was not extended to a consideration of the causes of the increased demands for power made by planers at reversals of their platens' motion; had it been intended as a treatise upon planer driving, this feature would have been discussed.

The author, Mr. Steen, was well acquainted with the fact that the inertia of the pulley wheels in a planer's drive is largely responsible for this phenomenon. Furthermore, this subject was only recently treated in our columns, in an article relating to the application of fly-wheel drives to some of the motor-driven reciprocating tools at the Collinwood shops of the Lake Shore & Michigan Southern Railway (see page 102, of our March, 1903, issue).

We are more than surprised that the *American Machinist* also takes the stand of questioning the advisability of applying fly-wheels to planer drivers in which it is known that heavy extra-power demands are made. It is stated in their editorial: "The fly-wheel will, no doubt, reduce the surge of current, but, in doing this, it prolongs the time during which the increased current must act," etc. Now this result is *exactly what is wanted!* It is not expected, nor intended, to reduce the *work* of reversal, but the great desideratum is to "prolong the time" during which the current acts, so that the objectionable peak of the load curve is flattened down. This will greatly reduce the severity of the shock to the motor and also will reduce the extreme and abnormal rush of current which is so detrimental to the electrical distribution circuit.

The *American Machinist* has also, in the editorial, inadvertently confused terms in stating that a motor of the constant-speed type is not "suited to the purpose" of driving planers, for which a differentially wound (over-compounded field) motor should be used. The differential wound motor, with over-compounded fields, is nothing more nor less than a constant-speed motor, the over-compounding being used purposely to maintain its speed constant by greatly increasing the torque in the armature at every tendency to slow down due to an increased demand for power. Mr. Steen's use of the term, "constant-speed motor," was merely that necessary to distinguish the type used from the variable-speed type, such as the multiple-voltage, double-commutator and other types.

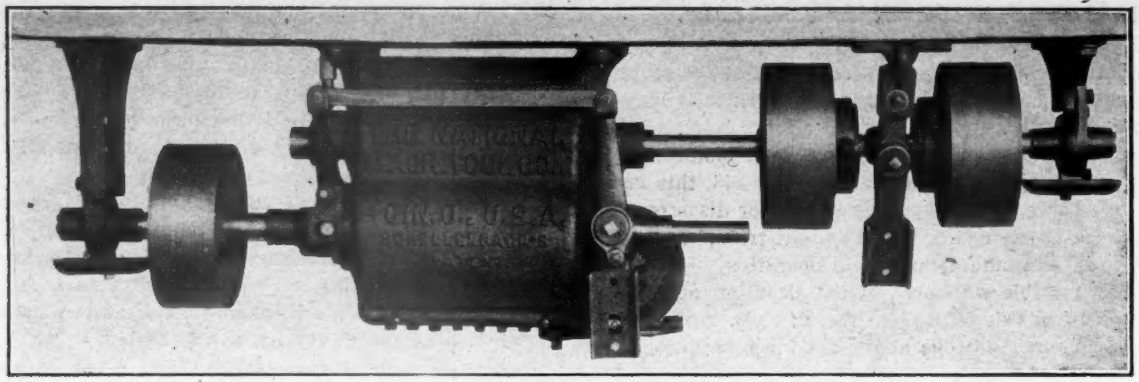

FIG. 27.—EXTERIOR VIEW OF THE SPEED "VARIATOR," AS EQUIPPED WITH REVERSING CLUTCHES FOR LATHE DRIVING.

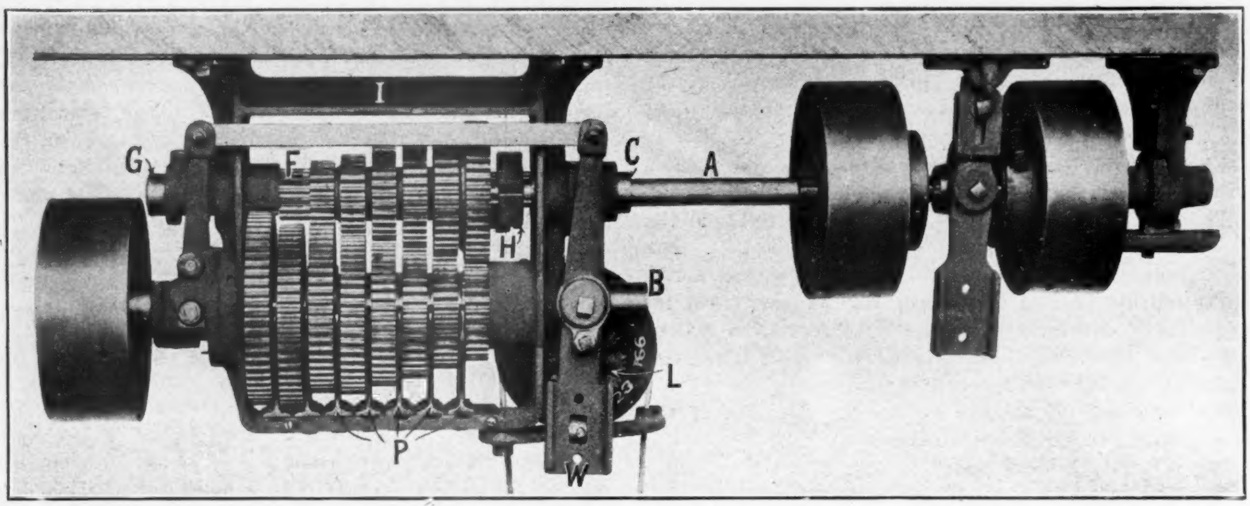

FIG. 28.—FRONT VIEW WITH COVERS REMOVED, SHOWING SHIPPER LEVER AND CONNECTING ROD TO SLOW-SPEED CLUTCH.

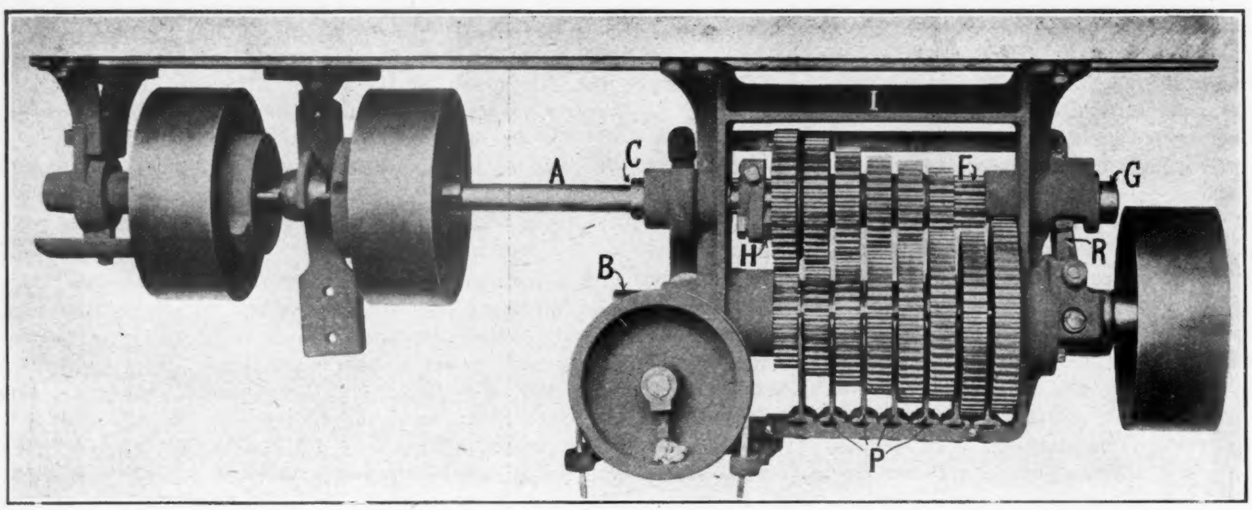

FIG. 29.—REAR VIEW WITH COVERS REMOVED, SHOWING ROPE SHEAVE FOR SHIFTING SLIDING CONE.

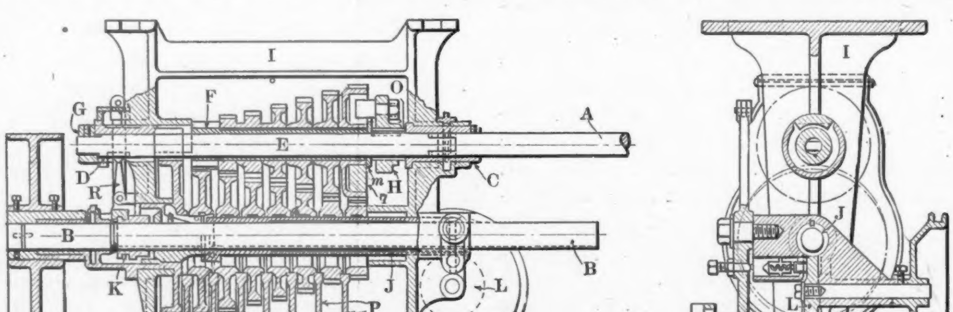

FIG. 30.—LONGITUDINAL SECTION AND CROSS SECTION THROUGH SHIPPER MECHANISM.

THE SCHELLENBACH VARIABLE-SPEED DRIVING MECHANISM.—NATIONAL MACHINE TOOL COMPANY.

MACHINE TOOL PROGRESS.

FEEDS AND DRIVES.

VI.

BY C. W. OBERT.

The third article of this series (page 98, March, 1903) described an independent, detachable feeding mechanism, applicable to lathes of any design, which is built by the National Machine Tool Company, Cincinnati, Ohio. The National Machine Tool Company are also building an independent variable-speed main driving mechanism of very interesting design which is applicable to the driving of all types of machine tools and other machinery requiring variable-speed drives. The latter device is of particular interest at the present time, owing to the greatly increasing use of electric driving by constant-speed motors. This speed "variator" makes available a wide range of speeds from a constant-speed drive, the changes being easily obtainable without the trouble of changing belts. It is being largely used in connection with constant-speed drives, both from motors and from line shafting, with marked success.

In the form shown in the exterior view of this device (Fig. 27) it is intended for use as a countershaft drive for lathes and other machine tools, but its construction is such as to enable it to be adapted for use in any manner or in any place where changes of speed are required between wide limits. And recent improvements in the method of changing the gear ratios have rendered it capable of withstanding the most severe service.

The principle of the speed variator is made clear in the following engravings. Figs. 28 and 29 present front and rear views of the mechanism with the protecting covers removed, while Fig. 30 shows a sectional elevation of the mechanism.

The general principle upon which the mechanism operates is the familiar one of two cones or nests of gears arranged upon parallel shafts for the proper meshing. The driving shaft A, Figs. 28-30, is carried in a sleeve (C), to which it is fastened to prevent end movement, and is milled out at the left-hand end in order to clutch with a sliding pinion shaft (E, Fig. 30). Mounted loosely on shaft E is a pinion (F), which has a long sleeve passing through, and upon which are keyed the larger gears of this cone of gears.

On the shaft E, which rotates at all times with shaft A, is a pinion (at the left of pinion F), which runs in mesh with the largest gear of the lower cone. The bushing D is slotted on its lower side to receive the upper end of the rocker R, and when this rocker is operated both bushing and shaft are moved endwise. There is also a flange (H) at the right-hand end, which is keyed and clamped to move with shaft E between the largest gear and the frame, and is provided with a taper wedge which fits a corresponding taper in the split friction ring Q in the gear. A washer (M) is placed on the shaft to serve as a retainer for ring Q, and between the washer and the sleeve C are vertical pins (O) passing loosely through flange H, which prevent the gear-cone from moving endwise. It may be seen that when the shaft is moved by the bushing D and rocker R the cone of gears will be locked to it or unlocked by the friction ring Q.

In most mechanisms of this kind the loose gears are in mesh with the driving gears all the time, so that all rotate at their respective speeds without regard to which gear is carrying the load; in this device the loose gears are bored out larger than the diameter of the shaft B, and when not in action drop out of mesh and simply hang suspended with their teeth just out of contact with the teeth of the driving gears. The hubs of the loose gears are prolonged so that when the gears have dropped out of mesh the hubs will be supported upon the separating pieces PP and keep the top surfaces of the bore of the gears out of contact with the rotating shaft.

The bore of these gears is the same as the outside diameter of the sliding cone, which lifts the gears into mesh with their drivers. This cone has a spring key and is moved along through the gears by the sliding sleeve J, the latter having on its under side a rack which engages with the gear L. The inside of each gear is beveled at the same angle as the outside of the cone, and the keyways provided in them are so located that when the cone is shifted from one gear to another the new gear shall be fully engaged and the old one entirely disengaged before the spring key can get into a keyway and so lock the driven gear to the shaft.

The largest one of the lower cone of gears is constantly in mesh with the pinion on shaft E; the hub of this gear takes its bearing in the bore of the boss on the lower left-hand end of frame I. This hub is provided with a friction clutch which is operated by the wedge collar K splined to the shaft B. The collar is moved on the shaft by the rocker R, this rocker having a fork at its lower end provided with a shoe fitting a groove in the collar.

The gear L which operates the sliding cone is keyed to the short shaft shown in the cross-section view (Fig. 30), which shaft has a rope sheave upon its end. The gear L has as many radial grooves milled in its face as there are gears on the lower shaft, and a spring-seated plug in front of it has a roller which engages these grooves. To the left of this plug is another plug made slightly conical to bear against the pointed screw shown in the lever W. This lever is connected at its upper end with rocker R by a flat connecting rod (shown in Fig. 28) and has a shipper handle bolted into the pocket shown at the lower end.

When the shipper is moved to the right it releases the friction in the large gear of the lower shaft and locks the upper gears to shaft E, for driving; when to the left, the upper cone is released and the lower large gear is locked to its shaft. Thus the power is removed from the upper gear-cone and the lower shaft driven slowly during the speed-changing operation; for the shipper must be moved to the left before the rope sheave can be turned to move the sliding cone.

Referring again to the cross-section, it will be seen that the pointed screw in lever W bears against the point on the spring-seated plug when the upper cone of gears is locked to shaft E. At this time the inner surfaces of the two plugs are in contact and the roller has not sufficient lateral movement to get out of the groove in gear L, but when the shipper is moved to the left, thus releasing the upper gears and locking the large gear below to its shaft, the pointed screw moves out of line with the point on the spring plug, and the sheave may then be rotated to any desired position. But should it be rotated so as to bring the lower sliding cone between two of the gears, the spring-seated plug will be forced out sufficient to lock the lever W in such a position that the upper gears cannot be locked to shaft E.

This attachment makes it possible to run the countershaft at a very high rate of speed without danger of breaking the gears when the speed is being changed. Also, with this arrangement the cone and key on the lower shaft can be moved very quickly from one end to the other.

This device approaches very closely to the ideal mechanism for the gradual shifting to higher or lower speeds which is characteristic of all frictional variable-speed devices. It is very strongly built, being intended for the most severe service, and has the great advantage of preventing double gear combinations which result in stripping gear-teeth, and also the possibility of severe shocks at speed-changes is eliminated.

The Twentieth Century Limited made a remarkable run from Cleveland to Elkhart on the Lake Shore on the night of May 24. The train arrived in Cleveland 1 hour and 32 minutes late, arrived at Elkhart 14 minutes late, and was on time at Dune Park, 35 miles from Chicago. From Cleveland to Toledo, 104.7 miles, was covered in 105 minutes, at 59.8 miles per hour. The engine was class J (AMERICAN ENGINEER, March, 1901, page 60). From Toledo to Elkhart the train was hauled by a class I engine (November, 1899, page 343) at a speed of 70 miles per hour, or 133 miles in 114 minutes. The train consisted of a buffet smoker, two sleepers and an observation car. This record is sent from the official train sheets by Mr. H. F. Ball.

LEAKY FLUES AND CIRCULATION

IN WIDE-FIREBOX LOCOMOTIVES.

BY JOHN PLAYER, MECHANICAL ENGINEER, BROOKS WORKS, AMERICAN LOCOMOTIVE COMPANY.

The leakage of flues in wide-firebox boilers is due to several different causes, some of which do not exist in narrow fireboxes. Among the chief causes of the trouble is a series of local conditions, the first of which is the class of fuel used; second, the inexperience of firemen and engineers in handling wide-firebox engines; third, the ignorance of the hostlers and those in charge of engines at terminals in handling this type of engine.

With regard to the type of fuel used, sufficient attention has probably not been paid in the design of medium-wide firebox boilers for burning bituminous coal to the proper grate area required for the different classes of coal. In narrow-firebox engines all that was necessary was to get in as large grate area as possible. In some of the wide-firebox designs too large a grate area has been introduced for burning the class of coal required. This subject is receiving closer attention than originally, and we expect ere long to be able to determine more accurately the correct grate area for different classes of fuel in different sections of the country. When this has been accomplished one of the causes of leaky flues will be removed.

With regard to the second item—inexperience of firemen: This gradually disappears as the firemen become more experienced in handling wide-firebox engines. Especially is this true if the roads operating them have intelligent traveling engineers or practical traveling firemen who conscientiously take hold of this subject and instruct the firemen properly.

Third, the ignorance of hostlers can be eliminated by conscientious work on the part of roundhouse foremen and others in charge of terminals to see that the hostlers handle the wide-firebox engines properly and do not, as is generally the practice, dump the fire out of doors, leaving the blower on full, and consequently inducing a great amount of cold air to come in contact with the flue-sheets.

The other causes of leakage of flues in wide-firebox engines are largely due to error in design or to restrictions placed by the railroad company upon builders, as follows:

In a wide-firebox boiler, owing to the grate being wide and short and of greatly increased area, a far more intense heat is obtained against the flue-sheet than in a narrow firebox, where the grate is narrower and longer, and in which a large proportion of the heat generated in the rear portion of the firebox becomes absorbed by the sides and crown-sheet. The flue-sheets and ends of flues in any tubular boiler will stand a certain degree of heat without injury. However, when this temperature is greatly exceeded injury is caused, from the fact that this increase of temperature has an annealing effect upon the ends of the flues, reducing the tension therein which has been created by rolling and expanding them in the sheets and by beading them over, these mechanical operations upon the flues having a tendency to harden them in the sheet. This action removes the tension therein and practically loosens them in the sheet, thus causing leakage. In order to guard against this increase of temperature in the ends of the flues and flue-sheet, better and freer circulation must be provided. This can only be accomplished by increasing the spacing of the flues, more especially the horizontal spacing, so as at all times to ensure an ample supply of water in contact with the sheet and flue ends. Some builders and many railway companies insist upon inserting a superabundance of flues in boilers, especially of the wide-firebox type, desiring to outstrip their competitors in the number of square feet of theoretical heating surface which they can show on paper as contained in their engines. However, it takes something more than theoretical heating surface to make steam and produce a satisfactory engine. A sufficient supply of water at all times in contact with the effective heating surface is far more necessary than an absurd amount of heating surface which cannot be utilized from lack of water to evaporate. A good and free circulation in a boiler is also of the greatest importance.

Another point which has been in the past, and is at the present, overlooked by locomotive designers, builders and users is the fact that not only must means for ample circulation be maintained, but also that this circulation must be uniform at all times, or, in other words, that a change or disturbance in the circulation produces detrimental results. It is, I think, a well-established fact that where two injectors are used, delivering water through two separate check valves located on opposite sides of the boiler at the front end, when the second injector is applied the steaming qualities of the engine are temporarily reduced. This is not due, as many would claim, without reasoning, to the additional amount of water injected into the boiler, but to a temporary disturbance in the circulation of the water in the boiler, for has it not been demonstrated that when the water is delivered from the second injector through a duplicate check or elbow at the same point as from the first injector, practically no reduction in pressure is observed when the second injector is applied? This would seem to prove conclusively that the effect on the steaming qualities was due to a disturbance in circulation caused by introduction of feed water into the boiler at another point. Furthermore, if this matter is given sufficient thought and the proper course of circulation in the boiler followed, does it seem right to apply the feed water against the flues half-way up the side of the boiler at a point where such application will materially disturb the natural circulation? Would it not be better to apply the feed water at the bottom of the boiler, toward the front end, providing a discharge backward toward the firebox flue-sheet, which is the natural course for the circulation to take? I have often noticed in boilers where the checks are applied to the back head or otherwise through internal pipes, discharging the water toward the front flue-sheet instead of splattering it all over the flues, that the application of the first or second injector with such arrangement has far less effect upon the steaming qualities of the boiler than with the use of side checks. This is simply due to the fact that although the introduction of the feed water is not in the theoretically correct course of the natural circulation in the boiler, it far more nearly approximates it than the erroneous application on the side.

If the matters I have outlined above are given proper attention, I fail to see why trouble should be experienced from leaky flues in wide-firebox boilers.

EDITOR'S NOTE.—Mr. Player's discussion is supplemented by a report of an interesting test of firebox conditions from another source, as follows:

A TEST OF FIREBOX CONDITIONS.

It is startling to be told that firebox sheets (side sheets) become dry, but this seems to be the fact when engines are working hard. The following is quoted from a report to the superintendent of motive power of a road where great difficulty is experienced in the cracking of side sheets of engines not more than 18 months in service:

"We have completed our test of engine No. — to determine the dryness of steam adjacent to the firebox. We first used glass water gauges on the sides, but these showed water at all times. We next placed gauge-cocks with extension tubes on the sides, about midway of the length of the firebox, the lower gauge being about 16 ins. above the mud ring, the second 6 ins. higher, and the fourth gauge about 40 ins. above the mud ring. The ends of the extension of the gauge-cocks projected through the water space to within ⅛ in. of the water side of the inside firebox sheet. These extensions were gradually shortened until the ends were ¾ in. from the inside sheet.

"We find from this experiment that when the engine is working hard there is a zone of practically dry steam covering the central portion of the side sheet; that is to say, the evaporation is so rapid that the sheet under these conditions is at times dry. The zone appears to start at zero and increase in thickness as it extends upward. At the center of the sheet there is about ¾ in. of practically dry steam. It is not con-

stant, nor is the distance from the firebox a fixed one, but it varies as the fire is pushed and the height of water increases. It appears that the zone is thicker when the water is low. The sudden lurching or swaying of the boiler appears to throw water against the sheet. This is evident from the fact that there may be a steady flow of steam for a few seconds, then water, and so on. Upon opening one of the cocks water will flow, later steam. If the cocks are left open, it seems as if a suction is produced on the inner end of the tube which draws the water out.

"We know that the temperature ⅛ in. from the inside sheet on the water side is at times 435 deg. This is above the temperature of steam at 200 lbs. pressure by 54 deg. The temperature may be even higher. This we shall demonstrate very soon. From the fact that all of the cracked sheets appear to be burnt it is evident that the temperature of the sheet is much higher than 435 deg. It could not on the water side be above 381 deg. at 200 lbs. pressure if water were constantly against the sheet. These facts support the theory of dry steam being present against the sheet under the above conditions."

On new engines this road has had many cracked and bulged side sheets. The cracks are nearly always vertical and the steel is covered with minute cracks, parallel and vertical, very closely resembling burnt steel; yet the steel was satisfactory under tests. The cracks have developed in the roundhouse when firing up or washing out. They are often accompanied by loud reports, indicating high internal stresses in the firebox structure. These facts indicate the necessity for a thorough study of firebox conditions, and they point to the importance of improved circulation.

LIGNITE BURNING IN LOCOMOTIVES.

BURLINGTON & MISSOURI RIVER RAILROAD.

ANALYSES OF SMOKEBOX GASES.

BY M. H. WICKHORST, ENGINEER OF TESTS, C., B. & Q. R. R.

While making some tonnage rating tests with a dynamometer car for the B. & M. R. R. about a year ago the writer also took occasion to make analyses of the smokebox gases and it was thought it would be interesting to give results of experience with the burning of lignite coal in locomotives in Montana on the Sheridan Division of that road, together with methods and results of smokebox analyses.

GENERAL REMARKS.

Along the line of the B. & M. R. R. in Wyoming and Montana two kinds of fuel are available for locomotives, namely, bituminous coal obtained from Cambria, Wyo., and lignite coal now obtained mostly from Dietz, Wyo., just out of Sheridan.

The bituminous coal is a low grade containing very high percentage of ash, quickly filling ash pans and firebox, although it has the redeeming feature that it does not readily clinker. The lignite coal is low in ash, but contains considerable moisture. The lignite coal requires but little labor in taking care of ashes and it does not fill up the firebox, but its worst feature is that it does not coke and is very light, and consequently throws sparks furiously with the ordinary front end construction for bituminous coal. The sparks, too, hold fire a long time.

Here is given the average analysis of the two coals:

	Cambria Bituminous. Per Cent.	Sheridan Lignite. Per Cent.
Moisture	5	17
Volatile Matter	5	35
Fixed Carbon	40	40
Ash	20	8

It will be noted in the above composition that the volatile combustible matter and the fixed carbon are about the same in the two coals, the bituminous coal containing a low amount of moisture and a high amount of ash, while the reverse is the case with the lignite coal. While the heat units generated by each coal would be practically the same, the heat actually available would be greater with the bituminous coal, due to the fact that with the lignite coal the great amount of moisture absorbs and carries away some of the heat. This moisture also becoming steam, takes up considerable room, thus increasing the volume of smokebox gases per unit of heat.

The considerable inconvenience and loss resulting from the high percentage of ash in the bituminous coal causing ash pans and fireboxes to fill up so very quickly, and expense of handling ashes led to experiments with lignite coal, particularly as lignite had been used for fuel in locomotives by some roads further south.

DESIGN OF FRONT END AND GRATES.

In changing a locomotive to burn lignite coal that has been burning bituminous coal the two important changes are; First, to use a front end arrangement that will be effective in preventing sparks, and, second, to use finer grate openings so as to prevent coal from dropping into the ash pan. The first engine changed was in January, 1901, and soon after that other engines were changed on the Sheridan Division. The front end arrangement as adopted for the Class D-3 engines, which are large consolidation freight engines, is shown in Fig. 1, and grates of Class R-2 engines, which are "Prairie" type freight engines, are shown in Fig. 2.

REMARKS ON COMBUSTION AND COMPOSITION OF SMOKEBOX GASES

The parts of coal that are of value for developing heat are the elements carbon and hydrogen, most of the heat being obtained by the combining of oxygen with the air with the car-

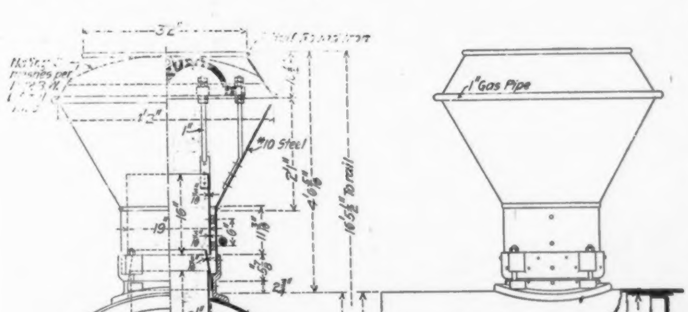

FIG. 1.

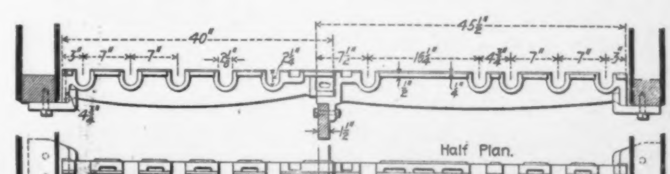

FIG. 2.

bon in the coal, but some also being obtained by the combining of hydrogen with oxygen. In an analysis of coal the volatile combustible matter and moisture represent the portion that volatilizes and forms when coal is thrown into the fire. The moisture is of no value for producing heat, but on the other hand is detrimental by absorbing heat and carrying it off, and is also detrimental by increasing the volume of smokebox gases. The volatile combustible matter in being converted into gas absorbs heat, but in combining with oxygen of the air gives out heat in considerable quantity. The components of the volatile combustible matter that are useful for heat production are carbon and hydrogen. The fixed carbon does not volatilize, but remains upon the grates until the oxygen of the air comes along to combine with it when it is converted into carbon monoxide or carbon dioxide, according to the quantity of oxygen available. The air necessary for combustion consists principally of two gases—oxygen and nitrogen; the active gas in combustion is oxygen and composes about one-fifth volume of the air, while the nitrogen is inert, taking no active part in combustion, simply acting to dilute the oxygen.

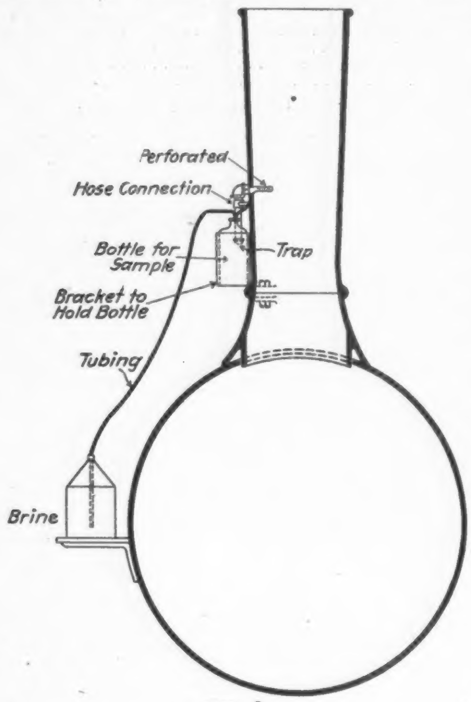

FIG. 3.

Carbon is a solid substance, but when it combines chemically with the gas oxygen under conditions of complete combustion the product is the gas carbon dioxide, chemical symbol of which is CO_2, heat being one of the physical effects of this chemical combustion. Where carbon combines with limited supply of oxygen the gas carbon monoxide (CO) is formed with a production of only about one-third of the heat in the previous case. Hydrogen is a gas which combines with the gas oxygen to form water (H_2O), which is liquid at ordinary temperatures, but is a gas or steam above 212 degs. at atmospheric pressure, considerable heat being one of the physical effects.

The following table shows the number of heat units developed by carbon and hydrogen when combined with oxygen, a heat unit being the quantity of heat required to raise 1 lb. of water 1 deg. F.:

	British Thermal Units Per Pound.
Carbon to CO_2	14,146
Carbon to CO	4,329
Hydrogen to H_2O	62,100

A judgment can be formed of the condition of the combustion going on in the firebox by collecting a sample of the product of combustion of smokebox gases and making an analysis of it. In such analysis the usual determinations are carbon dioxide, carbon monoxide and oxygen, no attempt being made to determine the amount of moisture in the product of combustion. If combustion were perfect with just sufficient air going through the grates to cause complete combustion, with no excess of air present, we would have in the smokebox gases simply carbon dioxide, nitrogen and moisture. The analysis therefore would show carbon dioxide, no carbon monoxide and no oxygen.

COLLECTION OF SAMPLE OF GAS.

For the purpose of collecting a sample of gas for analysis we used the arrangement shown in Fig. 3. The sampler consists of a perforated pipe extending a few inches into the stack and has a trap attached to it to catch cinders. The bottle in which the gas sample is to be collected was filled with a strong solution of salt to start with and this was syphoned out into a can on the running board as shown, the gas sample going into the bottle to take its place. The sample of gas is then taken into the test car behind the engine, where it is analyzed. The brine is syphoned out at such a rate as to let the gas sample cover a period of 15 minutes' firing. The gas sample is also handled under such precautions as to avoid its escape or mixture with air.

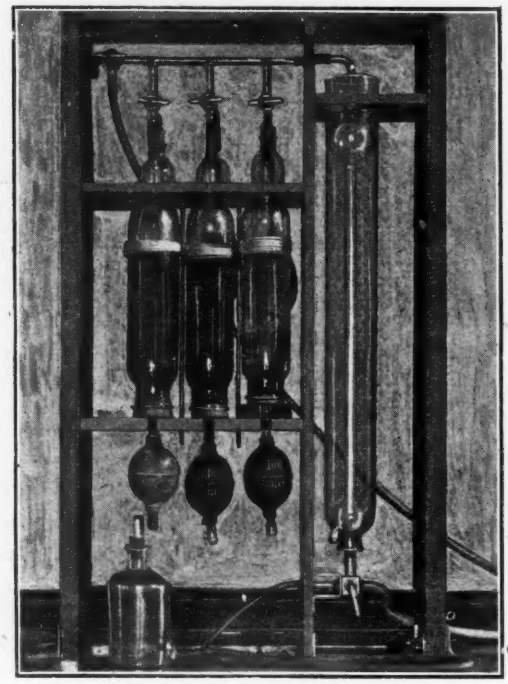

FIG. 4.

METHOD OF ANALYSIS.

The apparatus used for gas analysis is shown in Fig. 4, which is an Orsat gas apparatus, somewhat modified by and obtained from Mr. A. Bement, gas expert, Chicago.

Having obtained 100 cubic centimeters of the gas sample in this apparatus the carbon dioxide is first absorbed by a solution of potassium hydrate and its amount determined by reduction in volume. The oxygen is then determined by absorption in alkaline pyrogallic acid solution in a similar manner and carbon monoxide by absorption in cupric chloride solution. For further details on method of analysis I refer to books on gas analysis.

RESULTS OF ANALYSIS FROM BURNING LIGNITE COAL.

Perfect combustion with lignite coal would show about as follows: CO_2, 18 per cent.; CO, 0 per cent.; O, 0 per cent. This would be under ideal conditions. With bituminous coal, very good practical results would be about as follows: CO_2, 12 per cent.; CO, 0 per cent.; O, 6.0 per cent.

I give below a table showing about the average results obtained from analysis of smokebox gases by burning lignite coal:

CO_2	O	CO
11.8	5.9	0.3
12.9	6.0	0.3
11.5	5.9	0.4
14.1	4.6	0.7
12.1	2.9	3.7
13.6	4.8	0.0
12.0	7.9	0.0
13.6	1.8	2.9
13.9	4.0	1.2
13.1	4.7	0.4

THE PIECE-WORK SYSTEM FROM A PIECE-WORKER'S STANDPOINT.

BY H. B. KEPNER.

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Having been a piece-worker and made a practical study of the piece-work system for over five years, from its very inception almost, as applied to locomotive repair shops where at one time it was considered impracticable if not impossible; having labored in every department of machine shop work under the system during that time, and having had my attention called to the subject by articles appearing from time to time in various publications where a great deal of speculative argument is being produced both for and against the system, I am convinced that the amount of practical knowledge as to its fairness, as well as to the best plans for its adoption, is very limited and that we are yet to see it put into a great deal more general practice. So I believe it to be a subject well worthy of our most careful consideration.

As to the justice of the piece-work system from the standpoint of the employer, but little need be said, for to him it is a plain proposition of "Paying for what you get." However, as will be shown further on, much depends upon him whether the system proves a success or a failure, or rather whether it becomes popular or unpopular among his workmen.

But, upon the other hand, viewing it from the side of labor, much might be said and much is said. Many colored views are taken and considerable difficulty arises in the introduction of piece-work. So many biased opinions are expressed that the uninitiated are led to fear its possibilities and to distrust the fairness or the purpose of its promoters. But the honest, intelligent workman ever desires to be reasonable, and by such only can I hope these remarks to be kindly considered, so I would respect every workman as belonging to this class until he should prove himself utterly impregnable to reason. Such a one can only be convinced by experience.

Custom sometimes becomes a law and may control our judgment for a time, whether wisely or not. Prejudice may run away with our reason, but time will bring us to our senses, even though it may be after many a wasted opportunity. So laying aside one's prejudice and treating all men as being fair and reasonable, let us ask where there is any reason why piece-work should be unjust to the workman. Of course, it puts a premium upon skill and tends toward the "survival of the fittest" in reference to workmanship. The best workman may earn the most money, but why should he not?

Let us suppose that two young men of equal ability and like prospects should start to learn a trade and one should diligently apply all his energy, studying at night, working every hour he is able and faithfully striving to become a master of his profession, while the other is impatiently looking forward to the day when his term of apprenticeship shall have expired, seeking diversion at night, neglecting his duty by day, remaining off duty upon the least provocation, as some I have seen do, seeming to think that time is all that is necessary to serve in learning a trade and forgetting that practice alone can develop skill. At the expiration of their apprenticeship, which of these two young men would be the more competent workman and whose services would be worth the more? Naturally, we would answer that the faithful and most intelligent workman will accomplish the most and best work in a given time and his services be worth the most money, not alone for the amount of work done but for the quality as well, while the other fellow you will find to be the one who will do the most kicking against the piece-work system.

There are, however, many conditions to be considered in the successful introduction and practice of the piece-work system. A Chicago paper, in commenting upon this subject recently, mentioned as an objectionable feature, the unfair advantage it gives to unscrupulous and dishonest foremen who may, if they choose, materially affect the pay of any workman by the assignment of work. Certainly the charge that any foreman or minor official does, through personal feeling, make such use of the authority vested in him should be sufficient to disqualify him, but fortunately such cases are the exceptions and not the rule. So this objection should merely serve to warn us against such persons and bears no weight whatever against the system.

Then, some argue that it discriminates against the weak and less fortunate workman. Labor is often spoken of as a commodity as much as the corn that is sold by the farmer who, by the way, is a piece-worker in the extreme sense of the term, for he must provide his own tools, machinery, material and all facilities and then sell his produce by measure; then the man who lives farthest from the market or has the least facilities for delivering would require the most time in delivering a given amount of corn, for instance, but would we be willing to pay for it according to time taken to deliver it? For he surely would be less fortunate and possibly weaker physically than another who could have delivered the same in half the time. No, we should prefer to pay for it by the bushel. Why? Because it is cheaper, would you say? Not necessarily, but because it is more definite. It is a more business-like transaction.

And it is this characteristic that most strongly commends piece-work. So, treating labor as a commodity, it would furnish a similar example, and the only problem would seem to be in estimating the proper price to be paid for it. This can be accomplished with justice to both employer and employe, if each will be true to himself and both are honest with each other and will co-operate in the equitable adjustment of piece-work prices. There would be no occasion for fear or distrust if the workmen could be brought to understand that the companies do not desire to under-value their services nor to place prices too low, but that they do desire to reduce waste of time and energy by a systematic application of skill and labor such as this system affords. For here the company's interests becomes the workman's interests and vice versa, and the foreman experiences less anxiety as to how the workman may be putting in his time, for he feels assured that the men will utilize both their time and facilities to the best possible advantage.

In piece-work shops, the men are generally willing to concede that the system might be just, but they offer no objections upon other grounds.

First, and probably the most grievous, is that because of inexperience or lack of sufficient data, prices are set too low and the management may not be willing enough to readjust them.

Second, the material may vary in quality or conditions, so that the workman finds it impossible to duplicate the time—upon which the price was estimated—and fails on an average to accomplish the work in the required time. Or perhaps the amount of labor on a certain job may be increased by changes in the patterns or designs, without raising the price. All such things cause objections to arise, for which the system is not to blame, but may be due to local management or conditions that call for local investigation. In most places you will find the management fair, with a willingness to adjust matters satisfactorily to all concerned. But these and other common objections should be met fairly and the men satisfied, before they will be ready to acknowledge the justice of piece-work.

In order to successfully install the piece-work system into a shop it is important that the men should co-operate with the officials, and one of the greatest aids in this direction is in the inspector being a man of practical experience who is capable of placing a fair estimate upon the amount of labor and its value, and can win the confidence and respect of the workmen, who should rather regard him as a mediator than a scaler of prices.

Some men experiment with prices upon the theory that it is easier to raise a price than to lower one. This may be true in a sense, but the trouble is that usually even the best prices look very small to a day workman. So until the system becomes well founded and the workmen learn what is possible, and are better able to estimate the value of labor on a job, I believe it is preferable to risk over-paying rather than to pay too little, which discourages effort and enterprise.

(To be continued.)

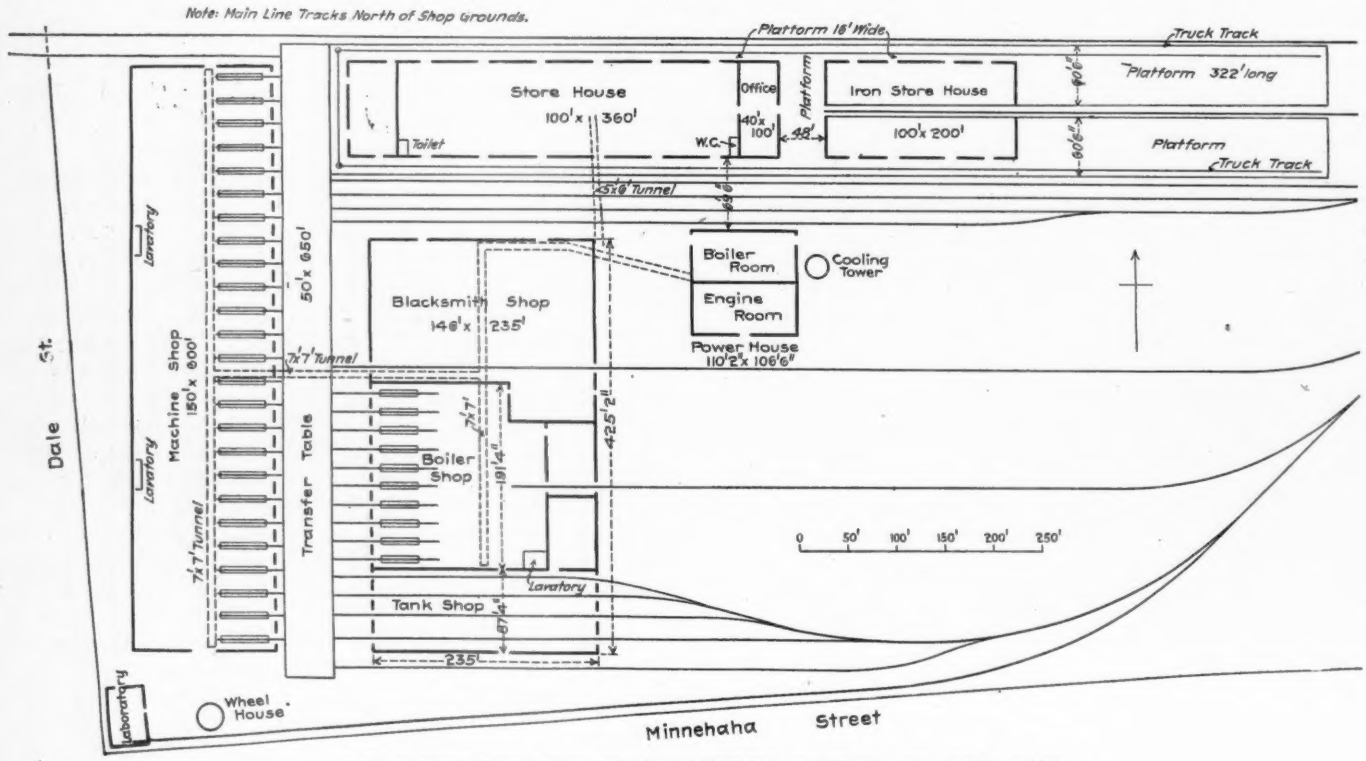
NEW SHOPS—GREAT NORTHERN RAILWAY.

AT ST. PAUL, MINN.

The new shops of the Great Northern Railway at Dale street, St. Paul, are progressing, and have reached a stage which justifies the publication of a ground plan of the buildings. When the machinery is located and the plant ready for operation we shall present a thorough, illustrated description and discussion of the problems and their solution, with particular reference to the electric driving, which is not yet ready for such treatment; and this is, by the way, the chief point of interest of the plant. There are no traveling cranes, except over machine tools, and the buildings have wooden roof-trusses, except the power station, which has a steel roof.

Three sides of the grounds are bounded by the main tracks on the north, Minnehaha street on the south and Dale street on the west, affording limited possibilities of extension. The location of the power-house was made with reference to the fact that alternating current will be used throughout for both lighting and power. The locomotive erecting and machine shop is in a building 150 by 600 ft., having three bays. In the east bay are 25 transverse pits. Next to these is the heavy machinery bay, and along the west side of the building are the light machines. East of the erecting shop is a 50-ft. transfer table 625 ft. long, which includes a track passing the north end of the locomotive shop, and serves the boiler, tank and blacksmith shop, as well as the storehouse. The blacksmith, boiler, tank, flue and truck shops are combined in one building 235 by 425 ft., the truck and flue shops being partitioned off east of the boiler shop and north of the tank shop. The power-house is 106 by 110 ft., located east of the blacksmith shop. North of the blacksmith shop is a large storehouse with a space of 100 by 360 ft., devoted to the store department, offices 40 by 100 ft. at the east end, and two rooms for the brass foundry and tin shop, each 48 by 50 ft., at the west end. An iron storehouse, 100 by 200 ft., lies east of the storehouse and is served by a track running through its center between two lines of roof-columns. East of the iron storehouse are two platforms 60 by 322 ft. At the southwest corner of the grounds is a 40 by 60-ft. laboratory and a building for wheels.

We are indebted to Mr. R. D. Hawkins, mechanical engineer of the road, for the plan.



NEW LOCOMOTIVE SHOPS, GREAT NORTHERN RAILWAY.—ST. PAUL, MINN.

LEHIGH VALLEY LOCOMOTIVE SHOPS AT SAYRE, PA.

At Sayre, Pa., the Lehigh Valley Railroad is preparing elaborate shop improvements for the repair of locomotives and cars, both passenger and freight. About $1,000,000 will be spent in a year upon the buildings of the locomotive plant, which will concentrate all of the heavy repairs at this point for about 800 locomotives. The equipment of the plant will begin about a year hence. The locomotive shop will be an immense building, 366 by 749 ft., the blacksmith shop 103 by 363 ft., the storehouse of the same size, and the power will be supplied from a well-planned power plant. The locomotive shop has 48 transverse pits in two sections, 60 by 627 ft. each, with the 156 by 627-ft. machine shop between them. At the end of the building will be the boiler shop, 121 by 366 ft. The machine shop will have two 60-ft. bays and a central bay 36 ft. wide. The latter will have a gallery to provide for the heaters, toilets, lavatories and lockers, the lighter machinery being placed under the gallery. Between each erecting shop and the machine shop is a "covered yard" 42 by 627 ft. for storage of wheels, castings and materials of all kinds. This arrangement places all locomotive work except blacksmithing in one immense building, with overhead crane service for all. The erecting shops will have 120-ton cranes on the upper level and 15-ton on the lower, the machine shop and "covered yard" cranes also being 15-ton capacity. This will be one of the most interesting railroad shop plants in the country, and the present state of the plans promises a highly efficient result. The plans are being prepared by Walter G. Berg, chief engineer, and H. D. Taylor, superintendent of motive power.

JUNE, 1903, CONVENTIONS.

The Master Mechanics' convention will be held at Saratoga June 24 to 26, and will be followed by the Master Car Builders', June 29 to July 1, with headquarters at the Grand Union Hotel. Circulars giving information as to hotel arrangements and railroad transportation may be had from Mr. J. Alexander Brown, 24 Park Place, New York.

The malleable iron brake jaw and dead lever guide illustrated in THE AMERICAN ENGINEER, April, 1903, page 158, are patented by the National Malleable Castings Company. This fact was not stated in the description.

NEW LOCOMOTIVE SHOPS.

READING, PA.

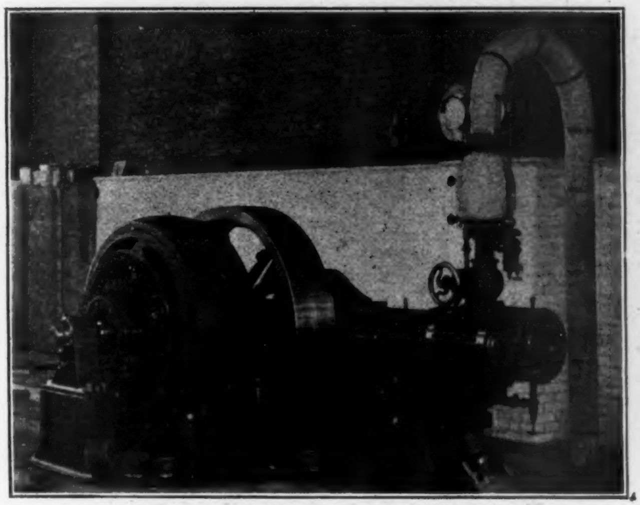
PHILADELPHIA & READING RAILWAY.

VI.

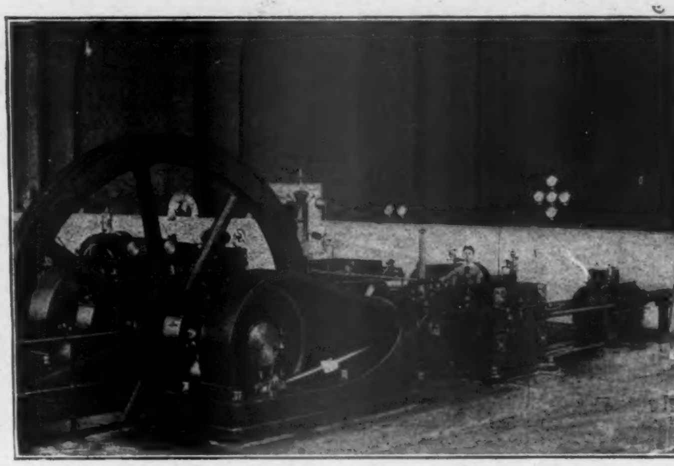
THE POWER PLANT.—*(Continued from page 185.)*

As stated in the preceding article descriptive of the steam generating equipment of the Reading shops power plant, while designed to supply electric current for all classes of service in the various departments of the company located at Reading, the plant was primarily intended to furnish the motive power for the machine tools in the locomotive machine shop. This consideration determined the location of the plant, inasmuch as a large proportion of the power developed at the plant is used in the locomotive machine shop.

It was found, in the design of the shop lay-out, that the cost of the feeder cables for the low voltage shop-power distribution would, by locating the plant opposite the center of power consumption, be reduced to one-fourth of that entailed by a location of the plant opposite one end of the machine shop.



THE 50-KW. GENERAL ELECTRIC CO. EXCITER UNIT.



THE TWO-STAGE, CROSS-COMPOUND AIR COMPRESSOR.—INGERSOLL-SERGEANT DRILL COMPANY.

It was, at first, intended to locate the plant at the south end of the shop yard, but this was abandoned on account of the saving in copper in feeder cables with a central location.

As may be seen from the lay-out diagram of the Reading Shops buildings, presented on page 10 of our January, 1903, issue, the location chosen is opposite the center line of the locomotive machine and erecting shops, with 110 ft. to clear between the buildings. The center of the power plant building is 276 ft. from the center of the machine shop. The feeder cables are carried into the shop by a spacious wiring tunnel.

All the distribution wires leading to the locomotive-shop buildings are carried in underground tunnels or conduits, so as to present no obstructions and to be entirely protected. The wires for the distribution to the car shops, depot buildings, etc., are run on overhead pole lines at the higher voltage, the longest transmission being 9,000 ft.

The power generating equipment in the engine room consists of one 300-h. p. tandem and three 600-h. p. cross compound engines, all direct-connected to 2-phase, alternating-current generators, and one compound-steam, 2-stage air compressor. All the engines are operating non-condensing at present; they are so designed that one cylinder may be bushed down to permit operating condensing if found necessary, although the low price of coal, on account of the proximity of the mines, will undoubtedly make condensing an unnecessary elaboration.

The three 600-h. p. engines are of the automatic cut-off type, with gridiron valves, built by McIntosh, Seymour & Co., each driving a 400-k.w. General Electric revolving-field alternator. The 300-h.p. tandem-compound engine is a Harrisburg automatic engine and drives a 200-k.w. alternator of similar type. There are also two 75-h.p. simple Harrisburg engines at the rear of the main engines, each direct-connected to a 50-k.w. direct-current dynamo, which furnishes current for exciting the alternators' fields and also for lighting the power-house. The steam pressure used is 150 lbs.

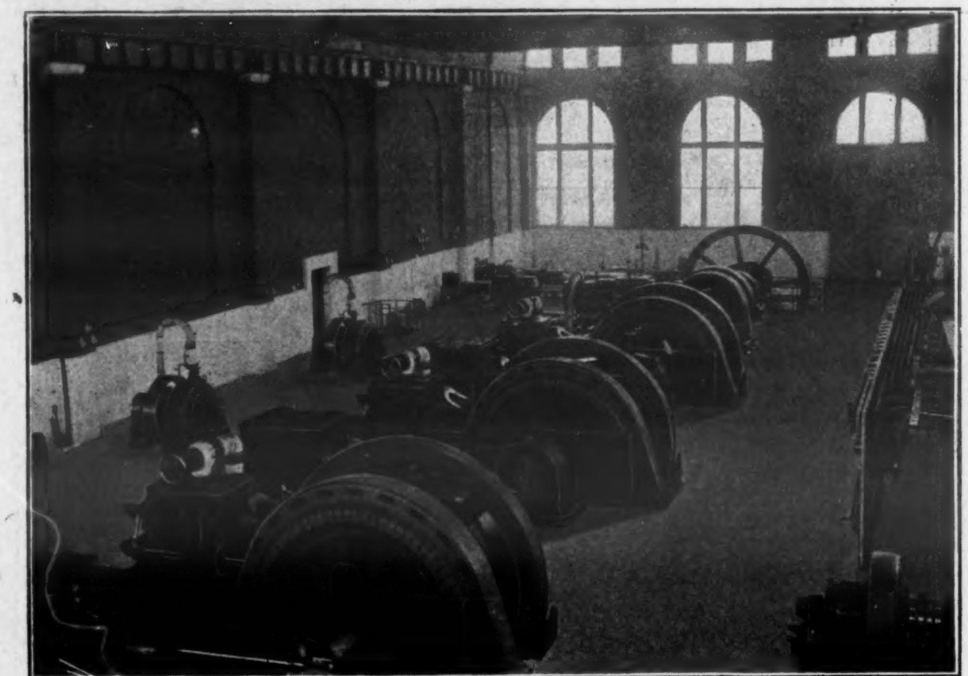
The general arrangement of the various engines and of the air compressors (of which only one unit has as yet been installed) is made clear in the foundation plan of the engine room of this plant presented on page 183 of the preceding (May, 1903) issue. The specifications of the engines and generators are presented below in tabular form.

The engines driving the alternators are guaranteed not to vary in the angular velocity of their rotational motion more than 2 degrees per cycle of the current wave; this is necessary in order to avoid the irregularities in the alternating current wave, so detrimental to parallel operation. The foundations for the engines, generators, etc., are of slag concrete of very substantial shapes and rest upon bed rock. A free space is left in the engine room basement around the foundations which provides for the steam piping, both high-pressure and exhaust, and the auxiliaries, such as the boiler-feed pumps, etc. This not only frees the engine room floor from all obstructions, but permits free crane movements and adds a very neat appearance.

Live steam is taken for the engines from the lower 16-in. steam header in the boiler room, passing through steam separator-receivers near each cylinder, each being located as close to the throttle as possible. This, together with the admirable arrangement of steam headers and piping, practically precludes the possibility of water entering the engines. The exhaust from the engines is all piped to a 16 and 20-in. exhaust

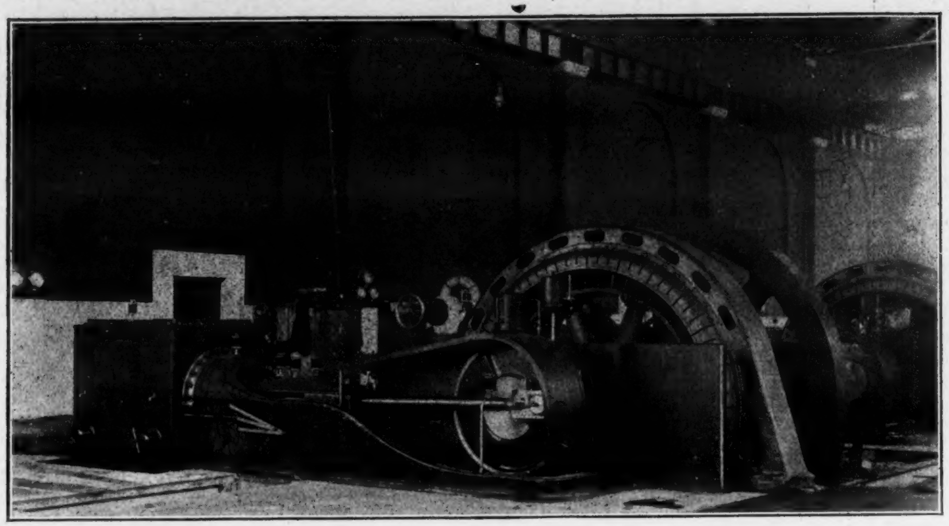
READING SHOPS POWER PLANT.— ENGINE-ROOM EQUIPMENT.

Builder of Engine.	Type.	Size.	Rev. per Min.	Sizes of Cylinders.		Builder.	Type.	Size.	Voltage.
McIntosh, Seymour & Co., Auburn, N. Y.	Cross-Compound	600 h.p.	150	19 and 32 x 30 ins.	Direct-connected to generators..	Gen. Elec. Co., Schenectady, N. Y.	Alternating-current, 2-phase.	400 kw.	480
Harrisburg Foundry and Machine Works, Harrisburg, Pa........	Tandem-Compound	300 h.p.	200	16 and 28 x 20 ins.	Direct-connected to generator..	"	"	200 kw.	"
Harrisburg Foundry and Machine Works, Harrisburg, Pa........	Simple-Automatic	75 h.p.	285	10½ x 10 ins.	Direct-connected to exciters....	"	Direct-current, multipolar.	50 kw.	125
....	....	....	900	....	Rotary converters	"	"	150 kw.	250-125
Ingersoll-Sergeant Drill Company, New York	Cross-Compound	280 h.p.	80	16 and 25 x 36 ins.	Driving air-compressor	Ingersoll-Sergeant Drill Company	Two-stage, with inter-cooler receiver	1,500 cu. ft per min. free air	Pressure = 125 lbs.

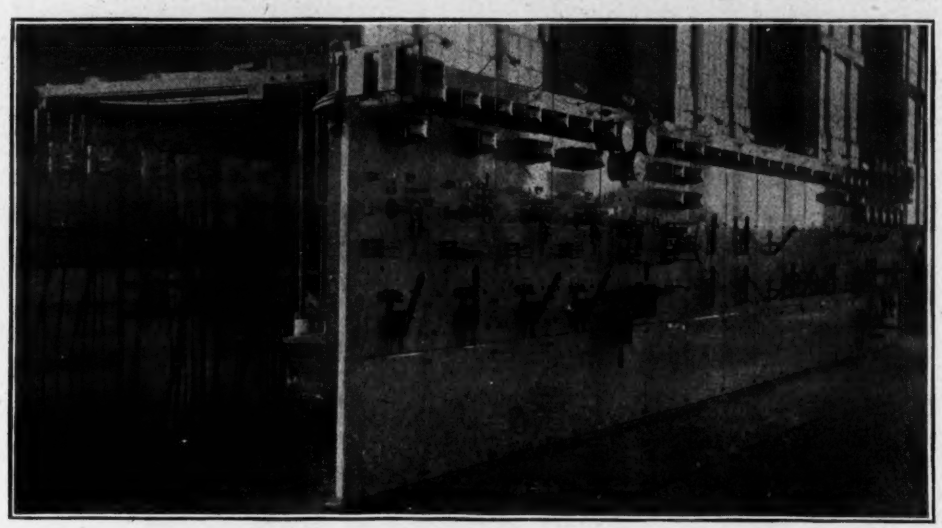


VIEW OF ENGINE-ROOM FROM NORTHWEST CORNER, SHOWING GENERATOR AND EXCITER UNITS.

VIEW OF ENGINE-ROOM FROM NORTHEAST CORNER, SHOWING ENGINES AND SWITCHBOARDS.



THE 400-KW. GENERAL ELECTRIC TWO-PHASE GENERATOR UNIT.—600-H.P. M'INTOSH & SEYMOUR ENGINE.



VIEW OF MAIN SWITCHBOARD (B) FOR THE SHOP DISTRIBUTION CIRCUITS. GENERAL ELECTRIC CO.

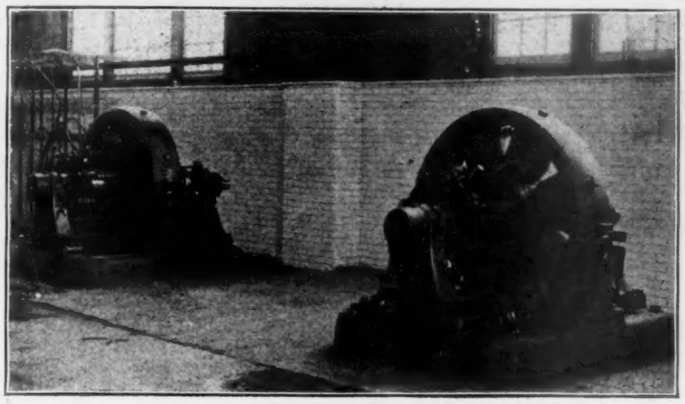
READING SHOPS POWER PLANT.—PHILADELPHIA & READING RAILWAY.

S. F. PRINCE, JR., *Superintendent Motive Power.*

E. E. BROWN, *Electrical Engineer.*

header in the boiler room basement, which delivers it either through a 24-in. pipe to the atmosphere or through a 20-in. steam heating main to the shop buildings. Connections are so made that either all or part of the exhaust may go to the heating system, the atmospheric connection being automatically controlled by a back-pressure relief valve. The exhaust passes through a 2,000-h. p. capacity Cochrane "open" feed-water heater and purifier.

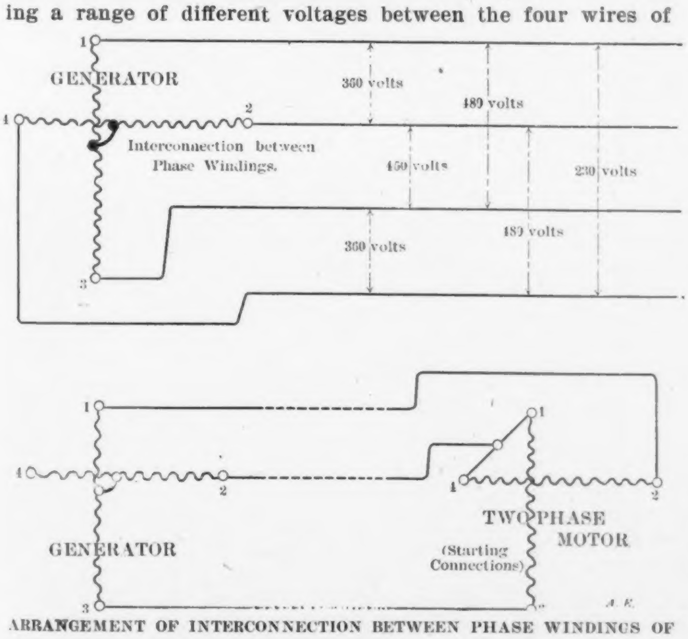
The main alternators are of the stationary armature type, wound to deliver two-phase alternating current at 60 cycles, and are specially arranged for parallel operation. The engine speed of all four units may be adjusted from the switchboard for



THE 150-K.W. ROTARY CONVERTORS SUPPLYING THE CRANE AND OTHER DIRECT-CURRENT MOTORS.

synchronizing through the agency of a small series motor mounted upon each engine's governor, which changes the tension of the governor spring through worm gearing. In this way the alternators' fields may be brought up into synchronism by one person at the switchboard, thus eliminating the necessity of another man adjusting the throttle.

The windings on each machine for the two different phases are inter-connected out of balance for the purpose of furnishing a range of different voltages between the four wires of



ARRANGEMENT OF INTERCONNECTION BETWEEN PHASE WINDINGS OF GENERATORS FOR OBTAINING DIFFERENT VOLTAGES FOR SYSTEM OF STARTING THE MOTORS.

the two-phase distribution system. This is done for the purpose of enabling the induction motors in the shops to be started without the starting compensators or auto-starters that would otherwise be necessary. The arrangement of interconnecting between the two windings is shown diagrammatically above, and the various voltages obtainable are indicated. The lower diagram shows the connections that are made between a motor and the current supply when starting the motor.

After the motor is brought up to speed the connections are changed to the normal running arrangement (1 to 1, 2 to 2, etc.), by means of a four-pole double-throw knife switch which permits either arrangement. Each switch, which is thus used for starting, is plainly labeled for the *starting* and *running* position, the special connections shown above being, of course, the starting position. No difficulty is experienced in starting motors under full load by this system up to 40 h.p., and all the complication and extra cost of the compensators is avoided. The operation in multiple of the generators is not affected by this simple arrangement of interconnecting the phase windings, which also entailed no extra first cost in the generators.

Two 150-k.w. rotary convertors are provided for furnishing direct current for the crane motors and the variable speed motors used upon machine tools. The two machines run in parallel on the direct-current end, delivering 250 volts, and have an equalizer connection to the secondaries of the pair of static 90-k.w. transformers supplying the alternating current side, by means of which is formed a three-wire system giving 125 and 250 volts. The sketch below shows the arrange-

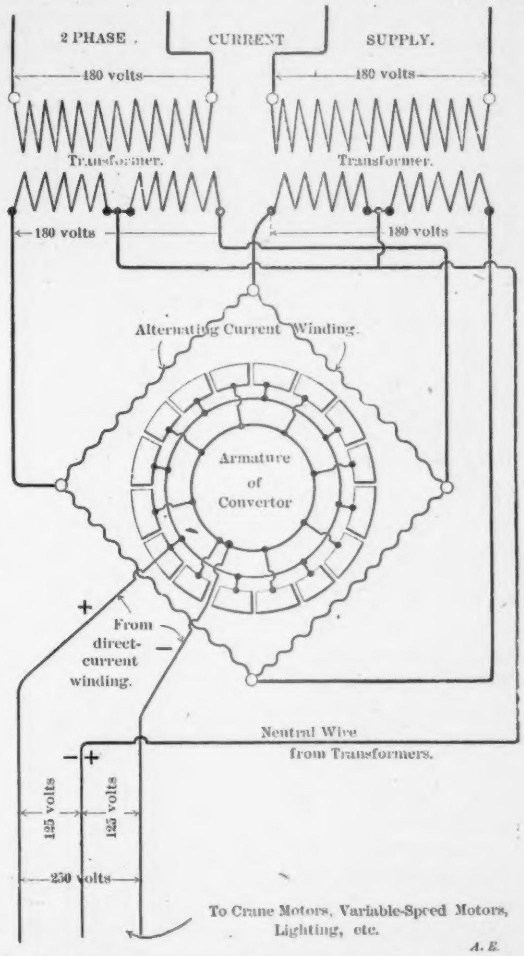


DIAGRAM SHOWING ARRANGEMENT OF ROTARY CONVERTOR AND TRANSFORMER CONNECTIONS FOR TWO VOLTAGES.

ment of connections for this service; the neutral wire of the three-wire direct-current system leads directly from the neutral points of the secondary windings of the pair of transformers. The motor ends of the converters are governed by induction regulators, by which the speed may be raised or lowered 5 per cent. from normal. The direct current ends are compound-wound, having equalizer connections, and maintain the voltage constant within 5 per cent. from no load to full load.

Two independent switchboards are provided, one termed switchboard A and the other switchboard B, as indicated on the floor-plan drawing, page 183 of our May, 1903, issue. Switchboard A controls all circuits leadng outside of the locomotive shop yard so as to embrace overhead line distribution (transmissions to the car shops, depots, pumping station at North Reading, etc.), while B controls all the underground shop distribution circuits. The importance of this arrangement lies in the fact that all circuits exposed to the

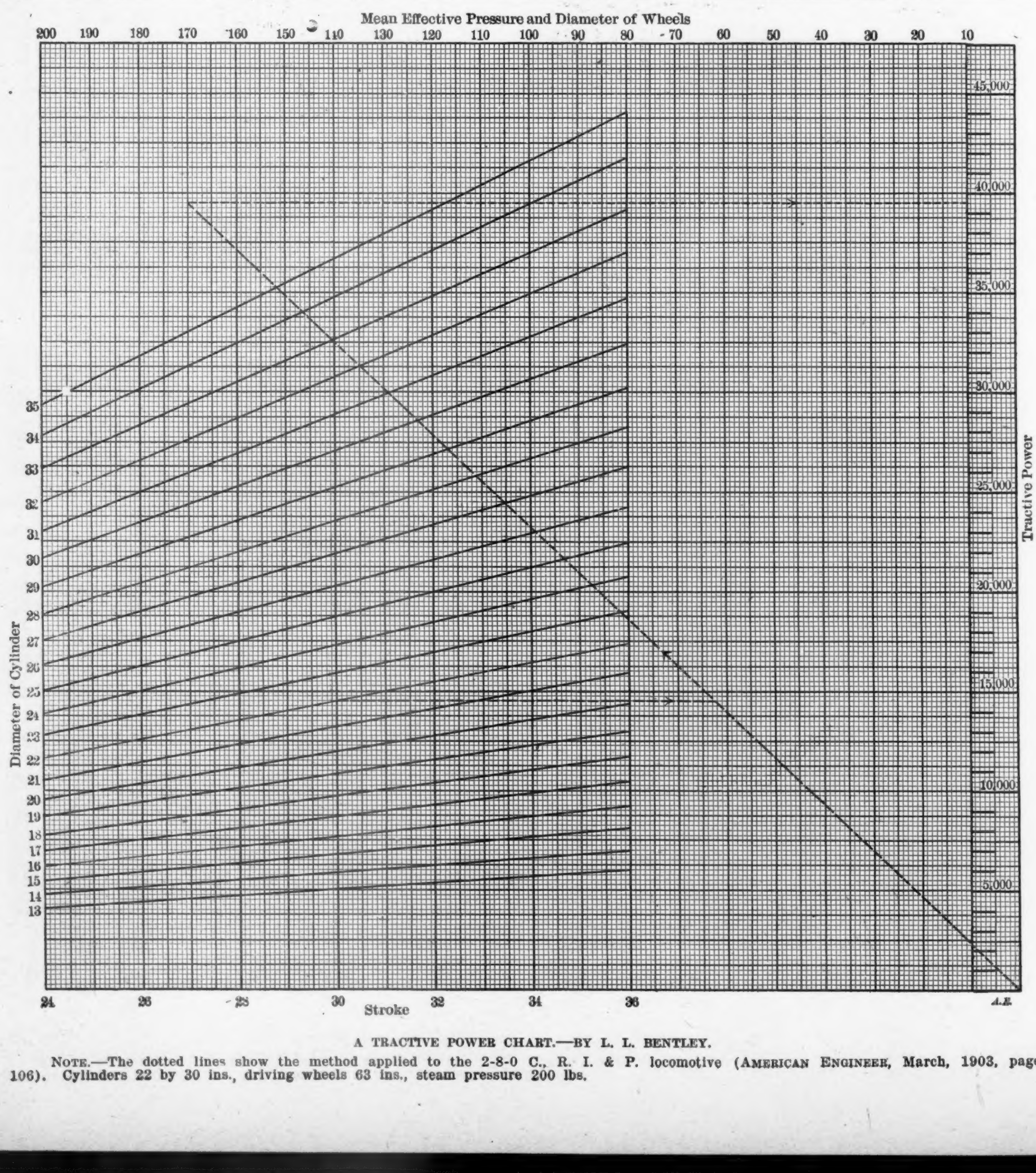
effects of electric storms are grouped on board A, where sufficient lightning-arrester protection is provided. The shop and underground distribution circuits, which are not exposed

SWITCHBOARD (A), CONTROLLING ALL OUTSIDE CIRCUITS, AND THE SERIES TRANSFORMERS FOR THE ARC-LIGHT CIRCUITS.

to lightning, are all controlled from board B. The switchboards, illustrated on pages 236 and 238, are both very attractive marble boards, erected upon metal framework, and were also furnished by the General Electric Company. They are located 8 ft. from the wall and there are 18-in. openings through the floor behind to accommodate the feeder cables from the engines and to the tunnel, all of which are carried in the basement. All the alternating-current circuits are controlled by oil switches.

Behind board A are located six of the new type of General Electric series transformers delivering constant-current at 6.6 amperes, for the series-alternating arc light circuits. Each transformer has a capacity of 50 arc lights, operated in two circuits of 25 each, and is insulated with oil. The total capacity of the transformers, 300 lights, will be distributed for lighting the yards of the entire properties of the company at Reading.

The distribution circuits are all led out from the switchboards underground through lead-covered cables, either to the shops or to the outlet to the overhead lines. An important feature of the distribution system is that, wherever located throughout the shops, all low-voltage wires are carried upon porcelain and the high-voltage wires upon glass insulators well up out of the way. This informs the workman at a glance which wires are to be avoided for safety.



A TRACTIVE POWER CHART.—BY L. L. BENTLEY.

NOTE.—The dotted lines show the method applied to the 2-8-0 C., R. I. & P. locomotive (AMERICAN ENGINEER, March, 1903, page 106). Cylinders 22 by 30 ins., driving wheels 63 ins., steam pressure 200 lbs.

CHART FOR TRACTIVE POWER OF LOCOMOTIVES.

BY L. L. BENTLEY.

While the general principle on which this diagram is constructed is not new, its convenience is such that it is hoped it may be of interest. In order that it may be reproduced a description of the construction is given.

Taking the usual formula for the tractive power of a simple engine

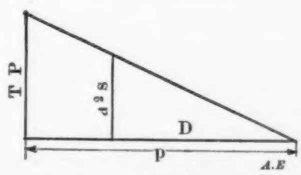
$$T.P. = \frac{p\,d^2 s}{D}$$

where T.P. = tractive power
p = mean effective pressure = a constant × boiler pressure,
d = diameter of cylinder in inches,
s = stroke in inches,
D = diameter of driving wheels in inches,

we can write it in the form of a proportion

$$\frac{T.P.}{p} = \frac{d^2 s}{D}$$

which can be expressed graphically by the sides of two similar triangles, as in figure.



The quantity, $d^2 s$, can evidently be expressed graphically by a straight line if we take s as the variable. Beginning at the left side of the diagram, the stroke (between the ordinary limits of 24 and 34 ins.) was laid off as abscissæ and ordinates erected the full height of the diagram. The units are:

$d^2 s$	1″ = 5,000 cu. in.
Tractive power	1″ = 5,000 lbs.
Mean effective pressure........	1″ = 20 lbs.
Wheel diameter	1″ = 20 in.

The value of $d^2 s$ were laid off on ordinate 24 to scale, and the same for ordinate 36, the corresponding points being joined by the inclined lines, the intersections with the stroke verticals giving the intermediate values of $d^2 s$. The tractive power scale was next laid off at the right and the driving wheel scale at the top. The fourth quantity, or mean effective pressure, was then found, the others having been assumed arbitrarily. This is done by substituting in the equation of the tractive power the values of 1 in. of scale. This coincides with that of the wheel diameter and is extended sufficiently to cover the necessary range.

The diagram is now complete with the origin in the lower right-hand corner. A thread attached at this point can be conveniently manipulated with the left hand and the course of the diagonal line traced without the necessity of drawing a line on the diagram.

To use the diagram find the diameter of the engine cylinder at the left, proceed along the inclined line to the intersection of the stroke vertical, thence along the horizontal to the intersection with the vertical representing the wheel diameter. Through this intersection draw a line to the origin and prolong it to intersect with the vertical representing the mean effective pressure. The tractive power is then read on the scale at the right.

For four-cylinder compound engines find the tractive power for the high-pressure cylinders and low-pressure cylinders separately from the diagram in the same manner as for simple engines. The sum of these results gives the total tractive power.

For two-cylinder compounds proceed as for four-cylinder engines and divide the result by two.

AMERICAN ENGINEER TESTS.

LOCOMOTIVE DRAFT APPLIANCES.

REPORT BY PROFESSOR W. F. M. GOSS.

XVII.

(Continued from page 164.)

[EDITOR'S NOTE.—The conclusions reached by Professor Goss are advanced out of the regular order for the purpose of bringing his summary before our readers at the time of the Master Mechanics' Association convention. A statement of the status of the tests will be found on the editorial pages of this issue.]

SECTION VII.

A SUMMARY OF RESULTS.

48. The more important conclusions to be drawn from the results of the tests may be briefly stated as follows:

1. All portions of the smoke-box which are in front of the diaphragm have substantially the same pressure; and, consequently, a draft-gauge attached at any point may be depended upon to give a true reading (Article 15).

2. The resistance which is offered to the forward movement of the air and gases between the ash-pan and the stack, may be divided approximately into three equal parts which are, first, the grate and the coal upon the same; second, the tubes; and, third, the diaphragm. It is significant that the diaphragm is as much of an impediment to draft as the fire upon the grate (Article 16).

3. The form and proportions of the stack for best results are not required to be changed when the operating conditions of the engine are changed. That is, a stack which is suitable for one speed is good for all speeds, and a stack that is suitable for one cut-off is good for all cut-offs. In future experiments of draft appliances, therefore, results obtained from a single speed and a single cut-off should be deemed satisfactory (Article 38).

4. Other things remaining unchanged, the draft varies with the weight of steam exhausted per unit of time; if the number of pounds of steam exhausted per minute is doubled, the draft, as measured in inches of water, is doubled; if it is halved, the draft value is halved (Article 45).

5. As regards the form of outside stacks, either straight or tapered may be used. From a designer's point of view, the tapered is the more flexible; that is, with the tapered stack, the draft is less affected by slight departures from standard dimensions. Incidental reasons, therefore, make the tapered form preferable. For best results, the diameter of a given straight stack should be greater than the least diameter of a tapered stack for the same conditions.

The term "tapered stack" used in this and other paragraphs signifies a stack having its least diameter or "choke" 16½ ins. from the bottom, and a diameter above this point which increases at the rate of 2 ins. for each foot in length (Article 44).

6. In the case of outside stacks, either straight or tapered in form, the height is an important element. In general, the higher the stack, the better will be the draft (Article 43).

7. The diameter of any stack designed for best results is affected by the height of the exhaust nozzle. As the nozzle is raised the diameter of the stack must be reduced, and as the nozzle is lowered the diameter stack must be increased (Article 41).

8. The diameter of a straight stack designed for best results is affected by the height of the stack. As the stack height is increased, the diameter also must be increased (Article 40).

9. The diameter of a tapered stack designed for best results, as measured at the choke, is not required to be changed when the stack height is changed (Article 40).

10. The precise relation between the diameter of front end, and the diameter and height of stack for best results, is expressed by equations (Article 42) as follows:

FOR STRAIGHT STACKS.

When the exhaust nozzle is below the center line of the boiler,

$$d = (.246 + .00123\,H)D + .19\,h$$

When the exhaust nozzle is above the center line of the boiler,

$$d = (.246 + .00123\,H)D - .19\,h$$

When the exhaust nozzle is on the center line h is equal to zero and the last term disappears, and there remains,

$$d = (.246 + .00123\,H)\,D$$

FOR TAPERED STACKS.

When the nozzle is below the center line of the boiler,

$$d = .25\,D + .16\,h$$

When the nozzle is above the center line of the boiler,

$$d = .25\,D - .16\,h$$

When the nozzle is on the center line of the boiler, h becomes zero, and

$$d = .25\,D$$

In all of these equations, d is the diameter of the stack in inches. For tapered stacks, it is the least diameter or diameter of "choke." H is the height of stack in inches and for maximum efficiency should always be given as large a value as conditions will admit. D is the diameter of the front end of the boiler in inches, and h the distance between center line of boiler and the top of the exhaust tip.

SECTION VIII.

49. *Problems for Further Study.*—The Chicago & Northwestern experiments (Master Mechanics' Association Proceedings, 1896) settled all questions relative to the form of the exhaust pipe and tip, and the AMERICAN ENGINEER Tests, as described in this report, are equally conclusive concerning the proportions of an outside stack when used in combination with nozzles of different heights. When, therefore, designers are content to employ plain forms of construction, the whole problem of front-end design may be considered solved. But conditions have of late arisen which enforce the use of stacks so short that the best proportions which can be given them do not yield satisfactory results. As a consequence, practice now tends along new lines for which there is little data that can be of service to the designer. That this deficiency may be supplied, it is necessary that the plan of tests already followed be extended to include other forms of mechanism. This is the more desirable since the results desired are not likely to be forthcoming from the road but, on the contrary, can best be obtained from the laboratory. The fact, also, that a large amount of data which will serve as a base line from which efficiencies of other apparatus may be measured, has already been collected from the Purdue locomotive, and the fact, also, that the work already done suggests the elimination of certain variables and a corresponding reduction in the number of observations hitherto considered necessary, all suggest the desirability of continuing the investigation along the general lines of the AMERICAN ENGINEER Tests. If this should be agreed upon, the work should, in the opinion of the undersigned, be made to include the following subjects:

a. *Inside Stacks*, by which is meant a stack of usual form, but which instead of being entirely above the smoke-box extends downward into the smoke-box as well as out through its top. Where conditions are such that the portion of the stack extending outside of the smoke-box is necessarily short, this arrangement is much used. The AMERICAN ENGINEER Tests have already included some observations on a straight inside stack of a single diameter, but the results obtained are not sufficient to serve as a basis for general conclusions. That the required data may be obtained, it will be necessary to employ stacks of at least three different diameters, and each diameter should have three different degrees of penetration into the smoke-box. Some additional work, also, may need to be done to determine the best form of the lower portions of the stack. It will be sufficient to employ the tapered form of stack only, and to have the outside length of stack constant.

The application of these stacks of different sizes will involve some cutting of the smoke-box, and the change from one stack to another may make the progress of the work slow, and consequently, somewhat expensive, but the results will be worth the pains for there is no other way by which the desired information may be obtained.

b. *Draft Pipes in Connection with Outside Stacks.*—It has been suggested that a draft pipe, or a combination of draft pipes, may be accepted as a complete substitute for an inside stack, and many roads are using them, apparently with good results. The experiments should deal first with a single draft pipe which should be varied in diameter and vertical position until the best diameter and position can be definitely chosen. After this, the process should be repeated in connection with a double draft pipe. A comparison of results thus obtained, with those obtained from the outside stack without draft pipes, should disclose the value of the draft pipes, and similarly a comparison of results obtained with those given by the inside stack should show whether the draft pipes are to be preferred to the inside stacks.

c. *False Tops Within the Smoke-Box.*—A number of railroads are now following the practice of blanking off the upper part of the smoke-box in such a manner that a stack of ordinary form may start from a point which is lower than the top of the boiler. The arguments in favor of such an arrangement are to be found in the fact that while the stack has the character of an outside stack, it can be made of greater length than would otherwise be possible. Whether there is any loss of efficiency resulting from the reduced height of the smoke-box, and, if so, whether it equals or exceeds the gain resulting from the increased length of the stack, are important questions. To settle this, false tops of at least three different forms should be experimented with, in combination with stacks suitable for each form. A comparison of results with those obtained under the provisions of preceding paragraphs would show to what extent, if any, such an arrangement is superior to others which are more common.

d. *Diaphragm.* As is well known, the diaphragm is not common in foreign practice, while in American practice its presence greatly impedes the forward movement of the gases. For this reason it would be well if it could be wholly omitted. It remains, however, to be determined whether there is any combination of nozzle and stack which in its absence will give satisfactory draft and at the same time draw equally on all tubes. The undersigned is not prepared to outline in detail a series of tests which will settle this question, but he believes it to be of importance, and that the means to be employed will be apparent as the work outlined in the previous paragraphs proceeds.

With full information concerning the relative value of the inside stack, draft pipes, the false top and the diaphragm, and with data which will permit any of these to be at once so designed as to give maximum efficiency, the problem of the front end, so far as it can be seen at present, is solved. While work of this character can be started and advanced slowly at small cost, it would be well if it could be vigorously pushed. To do this it will be desirable to have both the laboratory and the computing room manned at the same time, and to have assigned to the work an expert of sufficient ability and leisure to insure the prompt handling of all experimental results. Money will also be needed to supply and attach the special equipment and to defray the usual running expenses of the laboratory. While, therefore, much might

be done at small cost if plenty of time were available, the best policy requires that there be available a sum of from five to seven thousand dollars, at least four thousand being available for the first year's work. Upon this basis the remaining problems of the front end could soon be definitely solved.

EDITORS' NOTE.—The conclusion of the report and the intervening portion of the record will be printed in a subsequent issue.

(To be continued.)

CORRESPONDENCE

A DEFENSE OF PISTON VALVES.

Topeka, Kansas.

To the Editors:

I have been intending to write you ever since I read the paper by Mr. Gaines about piston valves at the meeting of the New York Railroad Club, February 20. I think the position Mr. Gaines takes is entirely untenable, as the simplicity of the piston valve as compared with the complicated method of balancing slide valves, as referred to in his paper, would certainly entitle it to a great deal of respect, and particularly when we consider that the machine work on a piston valve needs to be anything but high grade, whereas the balanced valve requires very careful work and some parts are extremely difficult to make. I have always felt that the piston valve was easier on the link motion, and particularly when carefully designed.

We know that the piston valve can be readily handled with one hand in large engines, and this has been a great surprise to engineers when using these engines for the first time. There are several arrangements for overcoming water in cylinders, and the one used by the American Locomotive Company is, I believe, giving excellent results.

In regard to the wear of piston valves and slide valves, I must say that my experience has shown that piston valves wear very much better than slide valves. I have seen cases where slide valves of the balanced type had to be removed and the valve seats refaced once or twice a week when in fast passenger service.

I believe that the piston valve is the best valve known at the present time for distributing steam in locomotives, and the large number of engines with this type of valve now being built by the American Locomotive Company and other builders shows that it is held in high esteem. Another feature is that if the piston valve is properly designed to admit steam on the inside that there are practically no opportunities for leaks around the front end due to the valve construction, as only the stuffing box will be exposed to steam, and that to exhaust steam, and by arranging the by-pass valves as is now done by the American Locomotive Company and by dispensing with the steam chest and other parts which are likely to leak, we have very much less chance for leaking steam at the front end to interfere with the view of the engineer.

It is doubtful whether it is desirable to get the clearance down to such an amount as is mentioned, as the compression will be entirely too great if the clearance be made too small. In some tests made by the Chicago, Burlington & Quincy several years ago it was shown that there was about as much difference of friction between the ordinary balanced valve and a piston valve as there was between an unbalanced valve and the balanced slide valve, and I hope you will put in evidence some information that will help forestall the discredit which has apparently been put upon the piston valve at this meeting. Yours truly,

G. R. HENDERSON,
Supt. Motive Power,
Atchison, Topeka & Santa Fe Ry.

THE SPECIAL APPRENTICE.

To the Editors:

Having noticed your editorial on page 140 of your April number, I beg to make a few comments upon the subject.

In the first place, if you or anyone else will explain in a satisfactory manner why a special apprentice in railroad shops should hold his position and work toward that of superintendent of motive power on any road, you will find five better reasons why he should get out of his job just as quickly as he knows how.

In my own case, having had seven years in universities and technical schools of the higher rank, and after working for two corporations doing research work and designing, I have given engineering lines the "go-by" and am now taking up the line of machinery salesman. What is more, I did not leave research work because of any failures in that or in designing.

Incidentally, it may be said that special apprentice jobs were looked upon at school as a last-chance affair, as they never carry a living salary. The time is passing when young college-educated engineers can be kicked around like yellow dogs at half the wages of a dago helper.

F. H. LACY,
San Francisco, Cal.

GROUP DRIVING OF MACHINE TOOLS.

BY J. C. STEEN.

Group driving may be considered from two points of view, one being the rearranging of an old plant, the other being the installation of a new plant. While it may be conceded that the individual method of driving is the preferable one, and usually the method to be desired, yet there are many cases where it cannot be adopted for various reasons, such as the greater cost of the large number of comparatively small motors and accompanying controllers, switches, circuit-breakers, wiring, etc. Especially is this the case when motors must be attached to old tools, as usually the design of existing old machine tools is such as to render the attachment of motors somewhat difficult without making the affair look patchy.

Again, the time required to make the necessary changes upon existing machines for individual driving may be a factor determining upon a group drive. The necessary time of draughtsmen, patternmakers and machinists cannot be spared, for they are usually busy with other lines of work.

Most of the reasons that determine for group driving apply equally to a new plant or to rearranging an old one, as in the case of a new plant usually many of the old machines are brought forward and continued in use. In either case it will usually be found advantageous to arrange the machines into a large number of comparatively small groups rather than a few larger ones. By this plan the tools or machines for certain classes of work can be placed in the most convenient position with reference to the general shop arrangements without giving any attention to a primary or main driving line shaft. The method of driving all machines from one common line shaft is responsible for many badly arranged machine shops.

Anyone who has ever had to lay out a machine shop under the old method and afterward had to do the same work under the grouping system will appreciate the advantages of the latter. With a new plant one usually has opportunity for obtaining a better arrangement of machines or tools than when rearranging an old one. One thing should be kept in view, as it deserves more consideration than is usually given; that is, to make proper allowance in space for future additions of machines as far as possible. Without proper provision in space allowance for changes, that which may be in the beginning a good arrangement will be a bad one when additions become necessary.

The experience gained in equipping thus a certain new shop recently built may be of interest. The question of power naturally came to the front. Of course, an engine is used as the prime source of power, and a generator was to be placed for lighting and testing purposes.

The question then came up as to how best to drive the small-tool department. The shop in question is of the three-bay type. One side bay contains the large planers, boring machines, radial drills, etc., all of which machines are driven from the main engine-driven line shaft. The center bay is used for erecting purposes, being covered by traveling cranes. The small-tool department is located in the third bay.

When locating the tools in the latter department they were so placed that in the process of manufacture all parts worked upon could be carried from the material storeroom through the various machine operations and returned to the finished

stock storeroom with a minimum amount of handling. For this department the use of two lines of shafting was deemed advisable. To drive these two lines from the main line shaft on the opposite side of the shop would require a rope or belt drive across the end of the building to avoid interference with the traveling cranes, but the natural objections to long belts or ropes, with their attendant idlers, carriers, take-ups, etc., led to the decision to use electric motors for driving, one for each line shaft, in the small tool department.

To determine the power required at each line shaft, each machine was carefully considered with relation to the work done upon it. No fixed formula or rule for required power was followed throughout, but each machine was considered separately and a power value was assigned which was considered as the maximum amount to be needed under average conditions. The table given below presents a list of the various machines, together with the amount of estimated power required for each one. One line shaft, which we may call A, is 130 ft. long and has 19 tools connected, while the other, to be called B, is 100 ft. long and drives 12 tools.

TOOL LIST.

Number of machines.	Line Shaft A. Type of Tool.	Estimated power required, horse power.
1	30-in. gear cutter	1½
2	No. 3 plain milling machines, total	3
1	No. 2 Universal milling machine	1½
1	28-in. upright drill	2
1	24-in. upright drill	2
1	Sensitive drill	½
1	No. 2 Universal grinder	4½
1	Jones & Lamson lathe	2
1	15-in. lathe	1
2	16-in. lathes	2
1	14-in. lathe	1
2	19-in. lathes, total	3
1	24-in. shaper	2
1	22-in. planer	3
1	Cutter grinder	1
1	Twist drill grinder	1
19	Total	31

Number of machines.	Line Shaft B. Type of Tool.	Estimated power required, horse power.
3	No. 4 plain milling machines, total	6
1	20-in. lever drill	1
1	20-in. chucking lathe	2
1	Jones & Lamson lathe	2
2	25-in. lathes, total	4
1	18-in. lathe	1¾
1	16-in. shaper	1¾
1	Cut-off saw	1
1	Centering machine	½
12	Total	20

These figures having been estimated as the maximum required, it was roughly assumed that at no time would more than half the maximum estimated power be required for the tools at once, and in case that this maximum should be exceeded, it would be for a short time only, so that the motors could readily take care of the excess load.

For line shaft A a new 15-h.p. motor was installed; this motor has a capacity of 15 h.p. at 750 rev. per min. For driving line shaft B, a machine which had been in use for several years as a generator was changed over to a 10-h.p. motor by altering the connections; it was speeded at 800 rev. per min. The speed of the line shafts is each 160 rev. per min.

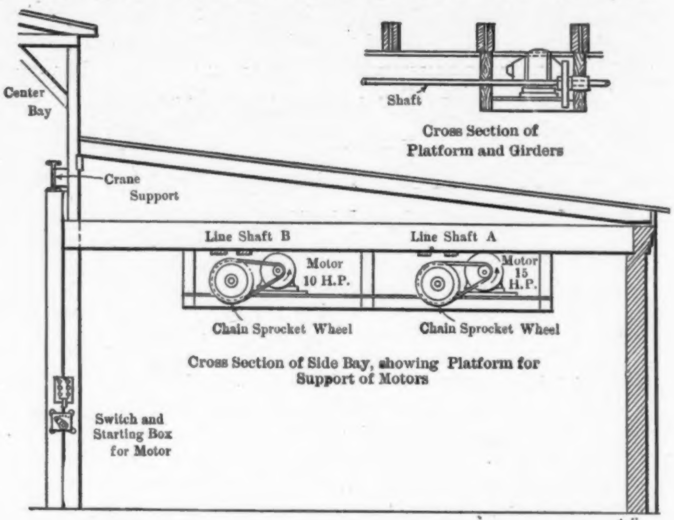
To avoid using belts, and to effect a compact arrangement, the motors were mounted upon a platform suspended from the overhead timbers, so as to come just below the line shafts, as shown in the cross-section of the side bay. The motors were connected to the shafts by Renold chains, being set as close to the line shafts as convenient. The switches and starting boxes were arranged upon opposite sides of a convenient column within easy reach of the floor, as shown.

It was found that the 10-h.p. machine would not run as fast when operated as a motor as its rated speed for use as a generator, but this was remedied by putting a small rheostat in the shunt field circuit.

So far the arrangement has proved quite satisfactory. Frequent observations of the current demanded by the motors by ammeter readings show that the power required for both lines varies from 15 h.p. to 22 h.p. (29 per cent. to 43 per cent. of the estimated maximum). It has shown as high as 25 h.p. (49 per cent.), but for a few moments only.

As an illustration of the capacity of a motor for taking care of an overload, it may be mentioned that owing to a slight accident the 15-h.p. motor was at one time disabled for about one day. When the accident occurred split pulleys of equal diameters were obtained, and both lines were thus coupled together and driven from the 10-h.p. motor. During the day the load averaged 18 to 20 h.p., sometimes going as high as 22 h.p. The motor carried the load all right, although it warmed up considerably while doing it.

This arrangement has some advantages. In case more machines are added and the motors become overloaded, it will be an easy matter to substitute a larger motor for the 15-h.p.



DRIVING ARRANGEMENT FOR THE GROUP LINE SHAFTS.

and the 15-h.p. for the 10-h.p., and use the 10-h.p. elsewhere. Or another method can be adopted: that is, to cut the line shafts up into two parts each and attach two more motors, thus having four group units instead of two. It has already been demonstrated in this installation that the advantage of being able to stop one group temporarily without interfering with the machines in the other group is one of no small importance.

The American Blower Company of Detroit, Mich., reports business excellent in all of its lines. Among the larger orders recently received they mention heating and induced draft apparatus for the Ironton (O.) Engine Co.; drying outfits for the Illinois Sugar Refining Co., to be installed at Pekin, Ill., and the Michigan Starch Co., to be used in their Traverse City plant; dry kilns for the Mengel Box Co. of Louisville, Ky., Brooklyn Cooperage Co. of New York, Buckstege Furniture Co., Evansville, Ind., Evansville (Ind.) Desk Co., Cadillac Cabinet Co., Detroit, and many others.

The Chicago, Burlington & Quincy Railroad has specified the Soule rawhide-lined dust guard for 1,000 cars which are being built by the Cambria Steel Company.

The 1,000 flat-bottom gondola cars with twin hoppers which the Chesapeake & Ohio Railway Company is having constructed at the McKees Rocks Works of the Pressed Steel Car Company, Pittsburg, are to be equipped with C. & O. standard arch bar trucks, pressed steel bolsters and brake-beams, manufactured by the Pressed Steel Car Company; Miner draft gear on 800 of the cars and Sterlingworth draft gear on 200, Chicago frictionless side bearings, and Westinghouse air-brakes.

"Resorts and Tours, 1903," is the title of the valuable little brochure published by the Boston & Maine Railroad passenger department, Boston. It contains a list of the resorts and hotels reached by the Boston & Maine Railroad and its connections, giving additional information in regard to the hotel rates and accommodations, and the round-trip summer excursion rates from Boston, Worcester and Springfield, Mass. The book is free and will be mailed upon receipt of address.

The rail and equipment department of the Walter A. Zelnicker Supply Company is represented by Mr. H. L. Schamberg with headquarters, for the present, at the Auditorium Hotel Annex, Chicago.

LINK-SLOTS AND PIN-HOLES IN M. C. B. KNUCKLES.

BY GODFREY W. RHODES.

ASSISTANT GENERAL SUPERINTENDENT, B. & M. R. R. R.

Has not the time come when the Master Car Builders' Association ought to make a vigorous move toward doing away with the link and pin slot and opening that now generally prevails in the M. C. B. knuckles?

The link and pin slot in the knuckle was one of the most serious weaknesses that confronted mechanical men in the introduction of the vertical plane coupler. Many will recollect the tirade that was made by the late A. M. Wellington in the *Railroad Gazette* in 1887 or 1888. He had visited the shops of the Chicago, Burlington & Quincy Railway Company at Aurora, Ill., where a collection of all the broken vertical plane couplers that were then being introduced, were kept. His emphatic summary was that the record was an "appalling

BROKEN KNUCKLES DUE TO LINK SLOTS AND PIN HOLES.

one." Members of the association will well recollect that one of the most frequent causes of breakages were the top and bottom knuckle lugs. Efforts were made to strengthen these parts, not only with as much material as the adopted contour lines of the coupler would allow, but also in improving the material. Careful records were kept for a time. The breakages, however, still continued, although, perhaps in a less serious way, but the friends of the coupler all hoped for the day when the abandonment of links and pins from freight train service would make this weakness in the knuckles no longer necessary, as when links and pins are no longer used there will no longer be any necessity for dividing the top and bottom lugs of the knuckle by the link-slot, nor for coring out the hole of the knuckle for the pin.

The law requiring railroads to use automatic couplers was to have been put into effect January 1, 1898. This time was subsequently extended two years. Since January 1, 1900, it has been unlawful to use link and pin couplers in our trains. Notwithstanding the above facts, the railroads in this country are still using a divided knuckle, not only in freight train service, but actually in passenger train service. Has the time not come when we can safely make a move to do away with the old-time custom of link-slots in the knuckles and pin-holes through the knuckle? By doing this we will very materially increase, not only the surface wearing part of the knuckle, but also practically do away with broken lugs. While we do not hear as much about broken lugs as we did when the vertical plane coupler was first introduced, we have reason to believe that an investigation of the subject on any of the railroads in this country will show that they are still occurring with entirely too great frequency. In order to verify this the other day we went into the Lincoln, Neb., yards of the Burlington & Missouri River Railroad and looked up an accumulation of broken knuckles that had been turned in as scrap. The foreman in charge advised us that he had shipped away all his broken knuckles six weeks ago. We nevertheless went over the accumulation since that time and actually picked out 43 broken lugs. Attached you will find a photograph representing the lugs referred to.

There is nothing more serious or disastrous on a railroad than a break-in-two with a freight train. Every railroad has had experiences in this line that are more or less distressing, through the loss of life and damage to equipment and railroad property. Doubtless this photographic exhibition of 43 broken lugs represents break-in-twos that have been more or less disastrous. With a matter so easily remedied, ought we not to get right after it? By referring to the picture one knuckle will be observed intact for the purpose of illustrating the top and bottom lug. As a matter of fact even in this knuckle, the lugs had been broken and crushed out through the pin-hole, thereby further illustrating how this now unnecessary pin-hole weakens the knuckle lugs. Here is an economy that it seems to us all railroads should get after at once. Some already are taking steps in the matter, but there is nothing that will make it become general so quickly as a live discussion on the subject by the Master Car Builders at their annual convention.

An important point upon machine tools is the method of changing feeds. The old way of doing this, by altering the change wheels at the end of the lathe, is much too slow. We cannot spare the time in these days for the workman to pull out a roll of paper and figure out the necessary change wheels required to alter the rate of cutting by 1-16 in.—if the man is on day work his thoughts are rather apt to wander off, and if on piece work his appreciation of the tool maker is likely to be unfavorable. All changes of feed should be done by means of gears which can be altered by the simple movement of a lever. It may be thought that these points are embodied in all modern lathes; however, this is not so, as only recently lathes have been purchased from first-class makers that not only require the gearing to be changed to alter the rate of feed, but also necessitate a clumsy alteration of change wheels merely to change the direction of the feed.

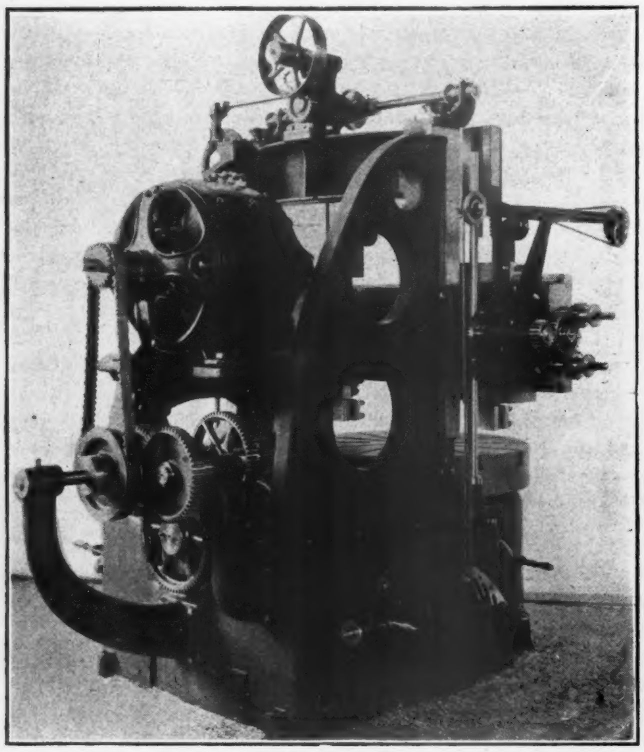
"My experience with the gearing on most lathes is that the difference is much too great between the last single speed and the first geared speed. As an example, the speed on the slowest single speed is 80, and the quickest, with the back gear in, is 30. Now, this difference is much too great. I am aware that a few makers now manufacture lathes with an intermediate gear, but the practice is not common by any means. In my opinion you cannot have too many changes of speed, so long as they can be altered quickly.

"This point, moreover, calls attention to the method of changing the gear. Take such a simple circumstance as putting in the back gear. Why is it that one lathe has the eccentric movement and another the plain spindle which requires to be pushed in and pulled out? I know the arguments brought forward by the makers of the latter arrangement, viz., that it is the best for the gearing, but is this not again the old question of the *life of the tool* versus its *efficiency?* One objection that I have to the plain spindle is that the shaft carrying the back gear protrudes through the headstock and necessitates that the face plate should be carried further away from the headstock. The eccentric is by far the quickest to operate, and if well made is, in my opinion, quite equal to the other."—A Large User of Machine Tools.

MOTOR DRIVEN MACHINE TOOLS.

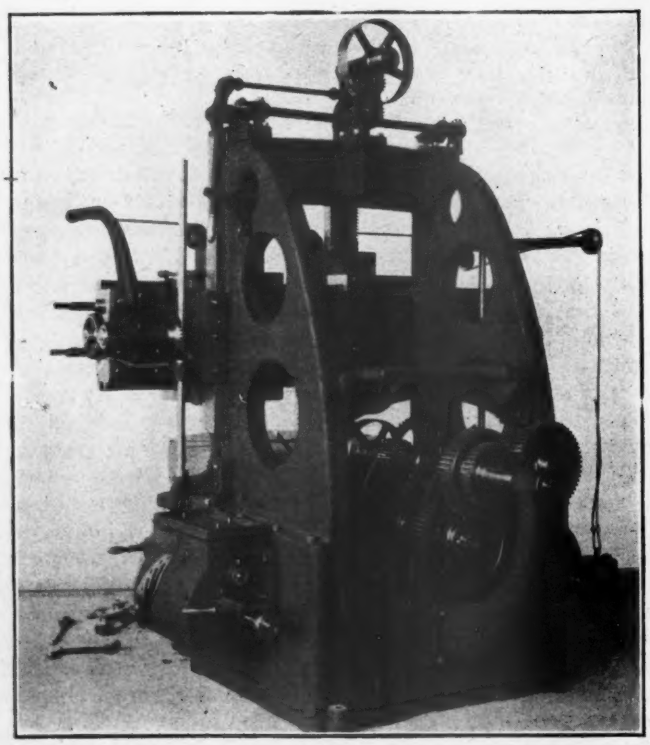
EXAMPLES OF INDIVIDUAL DRIVES APPLIED TO BORING MILLS.

An important feature of the development of railroad machine shop practice is the greatly increasing use of the boring mill. The large number of machining operations in railroad repair work that can be handled on the boring mill to far better advantage than upon the lathe is the factor that has been effective in bringing it into very extensive use in railroad shops. In the locomotive machine shop alone of the Collinwood shops five boring mills have been installed, of the following sizes: two 84-in., one 54-in. and two 37-in., all of which are equipped for individual driving by electric motors.



CHAIN DRIVE UPON A 41-IN. BORING MILL.—BAUSH MACHINE TOOL COMPANY.

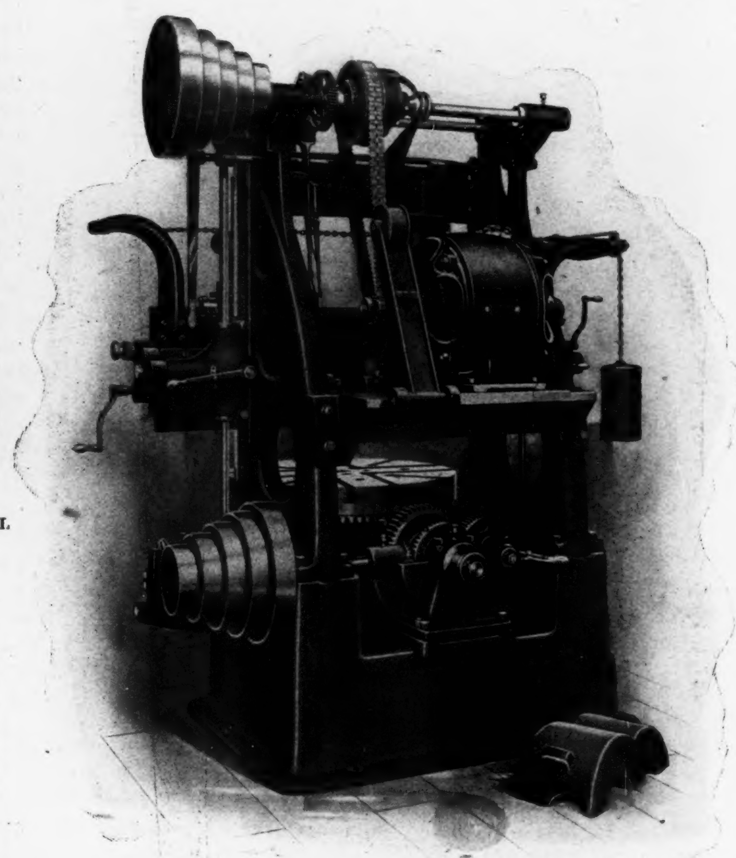
FIELD CONTROL VARIABLE-SPEED MOTOR.—GENERAL ELECTRIC CO.



REAR VIEW OF THE 41-IN. BAUSH BORING MILL, SHOWING ARRANGEMENT OF BRACKET BETWEEN FRAMES FOR SUPPORTING MOTOR.

Accompanying this development has arisen the question as to the best method of driving. In all applications to railroad machine shop work they have been installed in sizes sufficiently large to warrant the application of individual motor drives. Also the individual drive furnishing variable speeds is particularly applicable to the boring mill on account of the widely varying classes of work to which it is adapted. The result is that a large number of excellent and very interesting motor drives have been installed upon tools of this type, with very satisfactory results. Below are presented some representative examples of such motor drives which will indicate the trend of progress in this direction.

The two engravings at the left illustrate an excellent arrangement of mounting a motor upon a boring mill. The machine shown is the 41-in. boring mill built by the Baush Machine Tool Company, Springfield, Mass., and is equipped with a 4-h.p. motor. The motor is mounted upon a neat bracket bolted in between the uprights of the machine's frame,

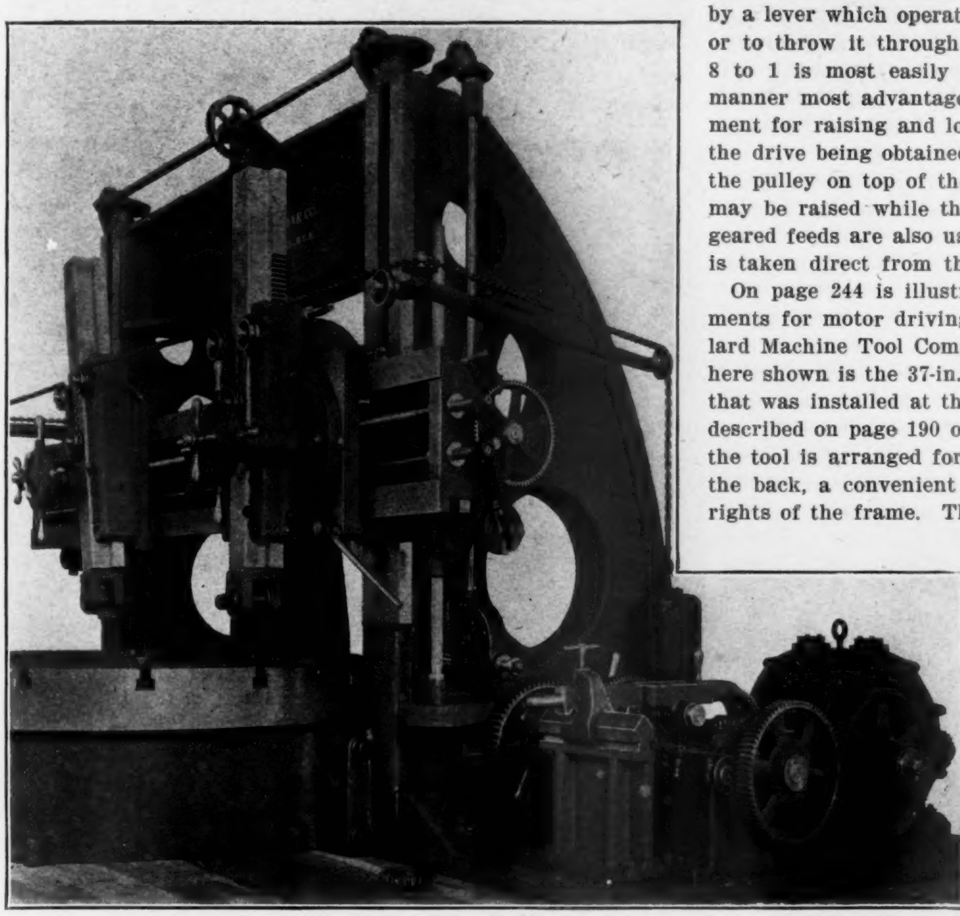


COMBINATION CHAIN AND COUNTERSHAFT DRIVE UPON A 37-IN. BORING MILL.—BULLARD MACHINE TOOL COMPANY.

CONSTANT-SPEED GENERAL ELECTRIC MOTOR.

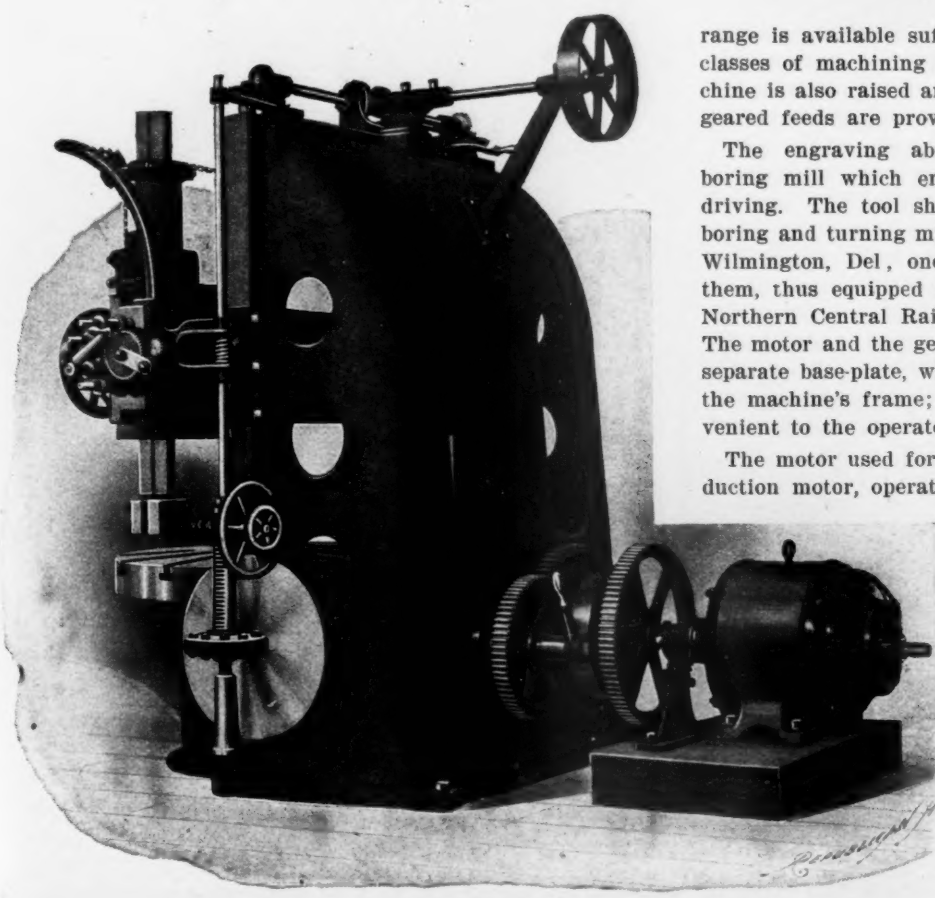
at the rear, just above the main driving shaft. The drive is through a 1¾-in. Renold "silent" chain, delivering direct from the motor shaft to the driving shaft, and running at a velocity of from 600 to 1,200 ft. per minute. The speed reduction at the chain is very low, the driving sprocket having 23 teeth and the driven 30 teeth. The speed reduction is obtained by gearing between the driving shaft and the spindle.

The motor is a 4-h.p. direct-current machine of the C-E type, made by the General Electric Company, Schenectady, N. Y., and has a 100-per cent. range (400 to 800 rev. per min.) by field regulation. Its rating of 4 h.p. is taken at its lowest speed—400 rev. per min. This speed range of 2 to 1 is quadrupled by two properly proportioned back-gear attachments arranged at the spindle as shown in the rear view at the left. The back-gear attachment is conveniently handled



GEARED DRIVE UPON AN 84-IN. BORING MILL, BUILT FOR THE PENNSLVANIA RAILROAD BY THE BETTS MACHINE COMPANY.

10-H.P. INDUCTION MOTOR (CONSTANT SPEED).—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.



GEARED DRIVE UPON A 51-IN. BORING MILL.—NILES TOOL WORKS.

MULTIPLE-VOLTAGE MOTOR.—BULLOCK ELECTRIC AND MANUFACTURING COMPANY.

by a lever which operates a clutch to connect the drive direct or to throw it through the gearing. Thus a speed range of 8 to 1 is most easily obtainable in small increments, in a manner most advantageous for the service. A power attachment for raising and lowering the cross-rail is also included, the drive being obtained by belting from the driving shaft to the pulley on top of the machine; in this way the cross-rail may be raised while the face-plate is at rest. Positive-drive geared feeds are also used upon this tool, the drive for which is taken direct from the spindle by spiral gearing.

On page 244 is illustrated one of the most recent arrangements for motor driving, which has been devised by the Bullard Machine Tool Company, Bridgeport, Conn. The machine here shown is the 37-in. Bullard boring mill, of the same type that was installed at the Collinwood shops, as illustrated and described on page 190 of our May (1903) issue. In this case the tool is arranged for mounting the motor self-contained at the back, a convenient bracket being bolted between the uprights of the frame. The drive is in this case also through a "silent" chain from the motor pinion direct to the countershaft, mounted at the top of the uprights. An idler pulley is provided to maintain the proper tension in the chain, which is not operated at a very high speed.

The motor used for this drive is a General Electric motor having a 100-per cent. speed range by field control. This is supplemented by a range of five different speeds, available from the cone pulleys and belt drive from the countershaft to the main drive shaft, and two additional speeds from the back-gear attachment on the spindle. This makes a very complete range of ten different speeds available, exclusive of those obtainable from the motor; thus, with the motor's range, a speed range is available sufficient to meet the requirements of all classes of machining operations. The cross-rail on this machine is also raised and lowered by power, and positive-drive geared feeds are provided.

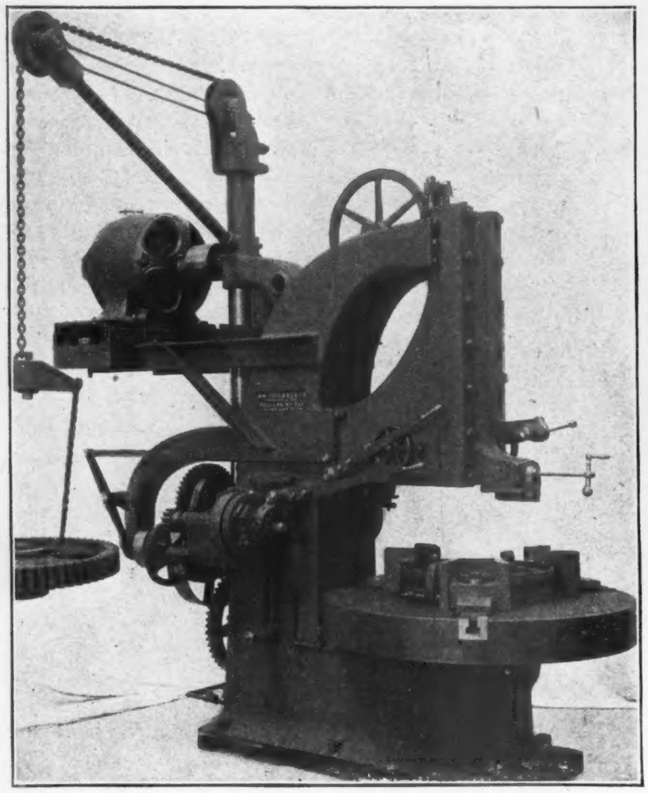
The engraving above represents an individually-driven boring mill which embraces the very latest idea in motor driving. The tool shown is the 7-ft. improved worm-driven boring and turning mill built by the Betts Machine Company, Wilmington, Del, one of which was recently furnished by them, thus equipped for motor driving, to the shops of the Northern Central Railway at Mount Vernon, Baltimore, Md. The motor and the gearing for the drive are mounted upon a separate base-plate, which is bolted to the right-hand side of the machine's frame; in this way the gear-changes are convenient to the operator.

The motor used for this drive is a 10-h.p. Westinghouse induction motor, operating at a constant speed. The range of speed-changes which are so necessary for a tool of this type are obtained by means of a series of trains of gearing through which the motor drives the spindle of the machine.

This gearing arrangement consists of two gear-cones of four gears each mounted side by side, one of which cones is driven by the motor and the other is connected to the driving spindle of the tool. The two gear-cones are not in mesh with each other, being mounted permanently separated just out of mesh. Connection is made for driving across any particular step of

the cones by means of the pinion shown mounted upon the movable lever above the gearing; this lever is capable of motion in two different directions by means of the rocker shaft support at the rear, and may be held in mesh at any point by the clamp upon the support at the front. In driving the pinion is merely lowered in between the two gears of the step desired.

This is undoubtedly the newest gearing arrangement for motor driving that has been developed. It provides four different speeds, which, together with the four additional speed combinations available from the back-gearing, makes a total of 16 different speeds easily obtainable for the main drive.



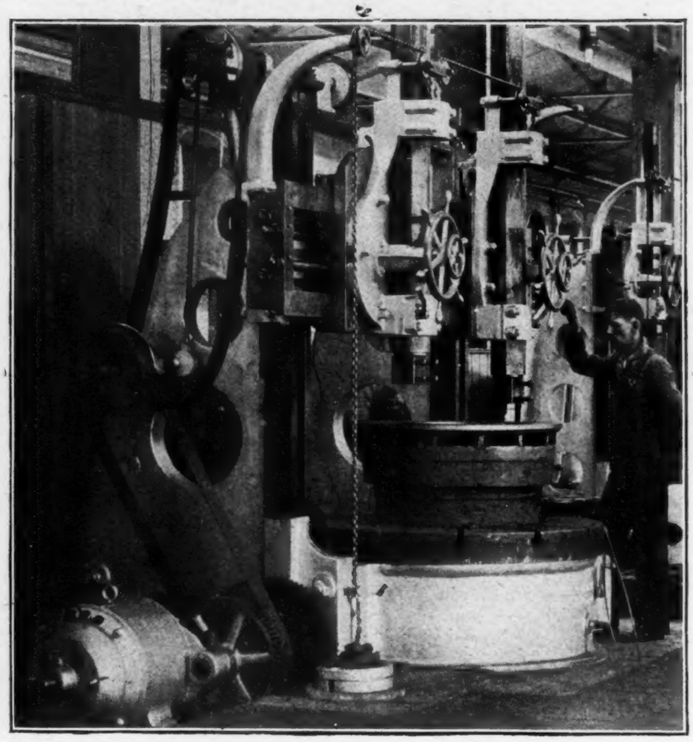
BELTED DRIVE UPON A 54-IN. CAR-WHEEL BORING MILL.—WILLIAM SELLERS & CO.

VARIABLE-SPEED GENERAL ELECTRIC MOTOR.

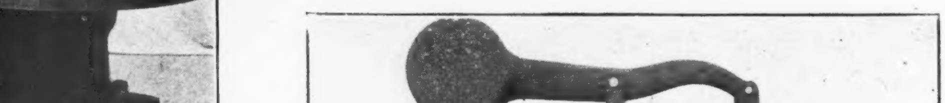
This is indeed a valuable arrangement for driving from a constant-speed motor where a variable-speed motor cannot be used. The Betts Company do not, however, advocate the use of a constant-speed motor where it can be avoided, preferring a variable-speed motor with a speed range of about 4 to 1 and operated by a controller, so as to avoid the necessity of making the gear changes. The latter method of driving by variable-speed motors is, of course, proving in practice to be far more convenient.

The engraving on page 245 is an illustration of a variable-speed motor drive applied to a 51-in. boring mill built by the Niles Tool Works Company. The motor used in this case is a 7½-h.p. multiple-voltage system motor, supplied by the Bullock Electric Manufacturing Company, Cincinnati, Ohio, and has a wide speed range in itself. It is mounted upon a separate sub-base bolted to the rear of the machine's frame, from which position it drives the main spindle direct through a gear reduction. The speed range available from the motor is doubled by a back-gear at the spindle drive, so that a very large range of speeds is possible for the drive. The compactness and convenience of the variable-speed method of driving are made especially apparent from this illustration.

The engraving immediately below illustrates a motor-driven boring mill at the works of the Bullock Electric Manufacturing Company, at Cincinnati. The tool is a large Niles boring mill and is driven by a 10-h.p. variable-speed motor operated upon the Bullock multiple-voltage system. It drives through a gear reduction and the usual back-gearing direct to the spindle



GEARED MOTOR DRIVE UPON A LARGE NILES BORING MILL AT THE WORKS OF THE BULLOCK ELECTRIC AND MANUFACTURING CO.



GEARED DRIVE UPON A 45-IN. CAR-WHEEL BORING MILL.—BEMENT, MILES & CO.

VARIABLE-SPEED MOTOR BY FIELD CONTROL.—WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY.

drive, thus furnishing a wide range of speeds. The controller for operating the motor is conveniently located on the base of the machine, near the operator's feet.

On the opposite page is shown an interesting motor drive upon a 54-in. car-wheel boring mill built by William Sellers & Co., Philadelphia, Pa. The motor is a 7½-h.p. variable-speed motor made by the General Electric Company. The method of mounting the motor is of especial interest in this case. It is carried by a bracket built up entirely of angles and channels, as is clearly shown in the engraving. The motor rests upon a bed of boiler plate, which is stiffened by channels beneath. This bed is mounted between angles bolted upon the upper side of the brackets, and is provided with an adjusting nut for raising it to tighten the belt by which the motor drives the machine. This makes a very strong and stiff, yet light and easily applied, construction for a motor support.

The remaining engraving opposite is an illustration of a motor drive as applied to a 45-in. Bement, Miles & Co. car-wheel boring mill. The motor driving this tool is a 10-h.p. Westinghouse variable-speed motor, which is connected directly to the driving shaft by a single large gearing reduction. A sufficiently wide range of speeds is available from the motor by field-resistance control to obviate the necessity of a back-gear attachment. The rheostat for the field control, as well as the main switch and starting box for the motor, are conveniently mounted at the side of the machine. The spindle feed and the wheel hoist are both operated by belt connection from the driving shaft.

LOCOMOTIVE TIRES, ALLOWANCE FOR WEAR.

In order to ascertain the practice of some of the leading railroads with reference to allowances for tire wear in preparing a standard for its own locomotives, the motive power department of the New York Central recently sent out a request for information, which resulted in securing the figures as arranged in the accompanying table. In a matter of this kind, in which so much expense is involved, uniform practice would be expected; but this table shows a variety of allowances. The minimum allowance affects other expenses than the cost of new tires, because usually the condition of tires determines the interval between shopping for general repairs. When from 7,000 to 10,000 miles may be made per 1-16 in. of wear the limit clearly becomes important as a commercial question. The last road in this list, under the notation "H," is the New York Central, and these dimensions have been adopted as standard practice on that road.

The New York, New Haven & Hartford Railroad has under contemplation a considerable extension of its high-speed electric equipment. Preparations are being made for the enlargement of its power house at Berlin, Conn., from which it is expected to operate its city street railroads in Meriden, 7 miles distant. It is probable that the successful third-rail service running out of Hartford to the West will be duplicated toward the East upon existing steam-operated branches, and also a rumor has gained current that the Harlem River branch running into New York City may be equipped for high-speed electric service for competition with the Portchester road now being built.

Our adherence to the tall chimney of our ancestors is worthy of a strict Confucian. A fan driven by a steam engine at 6 per cent. efficiency is still far more efficient than a chimney as a draft producer, provided other uses may be found for the heat contained in the gases. This excess heat may be greatly reduced by a radical change in the design of our boilers, while a further use for it may be found in heating air or water for warming buildings, or heating air for combustion.—E. S. Farwell, in *Engineering Magazine*.

"Cross-ties now cost more than twice the expense for rails." —P. H. Dudley, in *The Railway Age*.

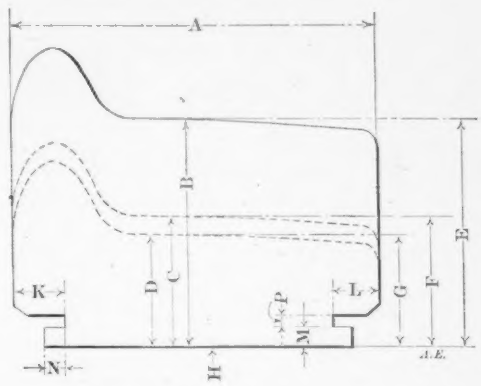


DIAGRAM OF DIMENSIONS.

ALLOWANCE FOR WEAR OF TIRES.

ROAD.	DESCRIPTION OF WHEEL.	Width. Inches.	WITHOUT RINGS. Inches. Thickness. New.	Minimum at Last Turning.	Minimum for Wear.	WITH RINGS. Inches. Thickness. New.	Minimum at Last Turning.	Minimum for Wear.	Min. Wheel Center with Rings. Inches.	Retaining Ring. Grooves. Inches.				
		A	B	C	D	E	F	G	H	K	L	M	N	P
A	74 inches Cent.	......	3	1 3-4	1 1-2	No Rings Used.				......	......	......	......	......
	68 " "	......	3 1-2	"	"	......	......	......	......	......	......	......	......	......
	62 " " Pass.	......	"	1 3-8	1 3-8	......	......	......	......	......	......	......	......	......
	56 " " "	......	"	"	"	......	......	......	......	......	......	......	......	......
	56 " " Freight	......	"	1 1-2	1 1-4	......	......	......	......	......	......	......	......	......
	5' " " "	......	"	"	"	......	......	......	......	......	......	......	......	......
	44 " " Switch	......	"	"	"	......	......	......	......	......	......	......	......	......
	Other Switch	......	"	1 3-8	1 1-8	......	......	......	......	......	......	......	......	......
B	Switch	......	4	1 1-2	1 1-4 1 3-8*	No Rings Used				......	......	......	......	......
	Road.	......	3 1-2	"	" "	......	......	......	......	......	......	......	......	......
C	......	......	3	1 1-2*	1 1-4*	3	*1 1-2	*1 1-4	56	M. 3-4	M. 3-4	5-16	3-16	5-16
				1 5-8	1 3-8		1 5-8	1 3-8		F.&B.7-8	F.&B.7-8			
	......	......	3 1-2	"	"	3 1-2	"	"	"	M. 3-4	M. 3-4	"	"	"
				"	"		"	"		F.&B.7-8	F.&B.7-8			
D	44 inch Cent. Con.	5 3-4	......	......	......	2	1 3-4	1 1-2	44	15-16	13-16	5-16	3-16	5-16
	45 T. Pass.	......	......	......	......	4	1 7-8	1 5-8	......	......	......	......	......	......
	60 T. Pass.	......	......	......	......	"	2	1 3-4	......	......	......	......	......	......
E	......	......	3	1 11-16	1 7-16	......	......	......	72	......	......	......	......	......
F	Freight	5 3-4	3	1 1-4	......	No Rings Used,				......	......	......	......	......
	Passenger	5 3-4	3	1 1-2	1 7-16	......	......	......	......	......	......	......	......	......
G	Freight	......	......	1 1-4	......	No Rings Used.				......	......	......	......	......
	Passenger	......	......	1 1-2	......	......	......	......	......	......	......	......	......	......
H	Pass. 62 inches and over	5 1-2	3 1-2	2 1-8	1 7-8	3 1-2	2 1-8	1 7-8	......	3-4	3-4	5-16	3-16	5-16
	" under 62 inches.	"	"	1 7-8	1 5-8	"	1 7-8	1 5-8	......	"	"	"	"	"
	Freight.	"	"	1 5-8	1 3-8	"	1 5-8	1 3-8	......	"	"	"	"	"
	Switch	"	"	1 1-2	1 1-4	"	......	......	......	......	......	......	......	......

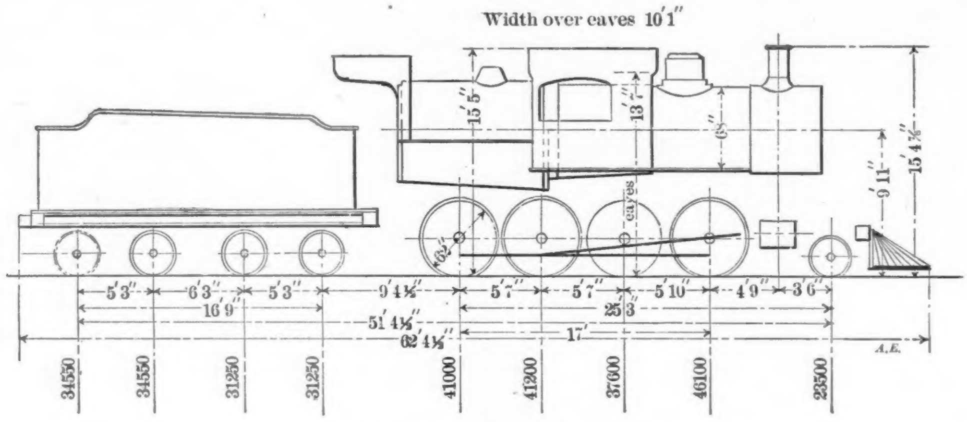
* According to weight of engine.

Some idea of the strength and stiffness embodied in modern lathes may be gained from the fact that a recent lathe, using four tools, has reduced a steel shaft from 36 to 28 ins. in diameter at one cutting with a feed of ¼ in. That is to say, the depth of the cut was 4 ins., this depth being divided among the four tools.

HEIGHTS OF LOCOMOTIVE BOILERS AND LOCOMOTIVE PROGRESS.

Discussions of the effect upon track of large locomotives and cars have led a correspondent to inquire the maximum height of the center of the boiler of an American locomotive, measured above the rails. The highest found in our record is that of a 2—8—0 (consolidation) type locomotive recently built for the Erie Railroad by the Baldwin Locomotive Works. This is known as "Class H 12" in the Erie classification and the height of the center of the boiler (68 ins. in diameter) is 9 ft. 11 ins. The height to the top of the stack is 15 ft. 4⅞ ins. The accompanying diagram is worthy of preservation.

The second in height of the center of its boiler is the 4—6—0 (ten-wheel) type, built in 1901 for the Chicago, Rock Island & Pacific by the Brooks Locomotive Works. This engine measures 15 ft. 7⅞ ins. to the top of the stack. The center of the boiler is 9 ft. 10⅞ ins. above the rail. If readers know of locomotives with boilers higher than these they will confer a favor by communicating the fact. This Erie locomotive boiler is probably 10 ft. high with new tires and new springs.



A LOCOMOTIVE WITH A HIGH BOILER.—ERIE RAILROAD.

Cylinders	21 x 28 ins.
Weight on drivers	165,900 lbs.
Total weight in working order	189,400 lbs.
Diameter of drivers	62 ins.
Ratio heating surface to grate area	32
Ratio heating surface to cylinder volume	198
Tractive power per lb. M.E.P.	199.16
Flues, number	298
Flues, length	13 ft. 2 3-16 ins.
Heating surface, flues	2,224 sq. ft.
Heating surface, firebox	167 sq. ft.
Heating surface, total	2,391 sq. ft.
Grate area	75 sq. ft.
Firebox, length	113 ins.
Firebox, width	96 ins.

Tender.

Capacity, coal	12 tons
Capacity, water	6,000 gals.
Weight, empty	52,400 lbs.
Weight, loaded	126,400 lbs.

Progress in locomotive proportions has been more rapid than anyone can possibly realize without a glance at the practice of a few years ago. It is interesting to note the suggestion contained on page 52 of this journal for February, 1888, to the effect that the center of a locomotive boiler might perhaps sometime reach the height of 9 ft. In that article the statement was made that between 1858 and 1888 the size and weight of passenger locomotives had doubled, and the question was asked: "Will this rate of increase continue, and in the year 1918 will there be passenger engines running which weigh 200,000 lbs. and over?" The reader will note that the new Chicago & Alton passenger locomotives weigh 219,000 lbs. which is 10 per cent. more than the prediction for attainment fifteen years hence. In June, 1900—less than three years ago—Mr. William Forsyth suggested the possibility that in 1905 the total heating surface of freight locomotive boilers might reach 4,000 sq. ft. In our June number of last year the Santa Fe 2—10—0 (decapod) was illustrated. It has 5,390 sq. ft. of heating surface.

Predictions for the future may be amusing, but their value is small. This rapid progress in size and weight emphasizes the relatively small progress in efficiency in the methods of utilizing the weight. It is time to turn attention to obtaining the utmost capacity from present weights, and this is the most difficult problem.

COMPARATIVE TESTS OF CALIFORNIA CRUDE OILS.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

A series of tests was made recently by the Santa Fe Railway on the crude oils found in California, to determine the relative evaporative values of the light, high gravity oils found in the southern part of the State and the heavy, low gravity oils found farther north. These tests were made both on the stationary plant at the San Bernardino shops, and to obtain service conditions on consolidation engine No. 719, having 21 x 28-in. cylinders, 31,100 lbs. tractive force and carrying 180 lbs. steam pressure. In both cases the water evaporated and the oil consumed were accurately measured in calibrated tanks, temperature and pressures taken, and in the case of the stationary tests, injector overflow measured and deducted, it being the intention to secure as accurate data as possible.

SUMMARY OF FUEL OIL TESTS MADE ON SAN BERNARDINO STATIONARY PLANT AND ENGINE NO. 719 WITH OILS "A," "B" AND "C."

Tests made on	Stationary Plant			Engine 719		
Kind of oil used	"A"	"B"	"C"	"A"	"B"	"C"
No. of tests made	5	7	7	5	4	4
Pounds water evaporated per pound oil	11.23	11.72	11.12	10.65	11.10	10.67
Pounds water evaporated per pound oil in per cent. using "A" oil on stationary and road as basis (100 per cent.)	100	104.26	99.02	100	104.23	100.79
Gravity of oil (Beaume at 60° F.)	19.03	19.56	12.1	17.7	19.1	13.5

The tests first made were to determine the difference between ordinary and southern California oil, as it is delivered in the oil cars from the fields, being a mixture of a large number of wells, and which we will call oil "A," and oil from a particular well in the same district whose analysis showed a higher thermal value than is found in the ordinary oil, which we will call "B." Reports of tests between these two oils on both road engine and stationary plant are shown in the table, and it will be noted that the difference in evaporative value of the two oils is small, being 4.36 per cent. in the stationary tests and 4.23 per cent. in the road tests, in favor of the special oil "B." The fact that two sets of tests made in such widely different service check so closely in the results would seem to indicate the accuracy of the tests. The oil "B" did not show the increased evaporation over oil "A" that a comparison of their B. T. U. would lead one to expect. This was explained by the fact that the well from which oil "B" was obtained was a heavy producer and ordinarily the oil from all of the wells is mixed together in the storage tanks, so that there

was not so great a difference between the two oils as had previously shown in their analyses.

Other tests made with heavy, low gravity oil "C" show an evaporation surprisingly close to that of the lighter oils "A" and "B" in spite of the marked difference in the per cent. of kerosene, gasoline, asphaltum, etc., present in the two oils.

Below is a summary of an analysis of the two oils:

	"A"	"B"	"C"
Calorific value B. T. U.	16,492	18,960	17,112
Per cent. sulphur	2.22	3.4	2.
Per cent. gasoline	5 to 20	4.6	none
Per cent. kerosene	36.88	23.	20.25
Per cent. residue (about)	25.60	72.	70.75

It will be noted by referring to the tests that the temperature of the oil as it went to the burner was very much higher with oil "C" than with the lighter oils "A" and "B," because the pressure of such a large asphaltum base made the oil very sluggish and required considerable heat before it would feed down to the burner freely. On the first road test made with this oil (C) the engine left the terminal with the temperature of the oil about 80 deg. F., and for about half an hour, or until the heater coil could get the oil hot, the fireman kept the oil feed valve wide open, and in spite of this the steam pressure ran back about 50 lbs.

All of these are California crude oils. Oil "C" is very thick, almost like asphalt when liquified by heat. The oils "A" and "B" are in appearance ordinary liquid crude oils and are obtained in southern California, while "C" is obtained at about the center of the State. It is interesting to note that although the appearance and analyses of the oils differs widely, yet one may be made to do as good work as another. It is also interesting to see how closely the tests on a stationary boiler and on locomotives agree with each other.

This information was furnished by Mr. G. R. Henderson, superintendent of motive power. The tests were carried out by Mr. G. R. Joughins, mechanical superintendent of the coast lines, the data having been taken by Mr. R. S. Wickersham, assistant engineer of tests.

A student grade of membership has been established by the American Institute of Electrical Engineers, conferring upon students regularly pursuing electrical studies the following: 1. The privilege of being present at all meetings of the Institute, except such business meetings as relate to the management of the Institute. 2. The privilege of receiving the regular announcements and printed copies of monthly transactions. 3. The privilege of purchasing the semi-annual bound volumes of the transactions of the Institute at the price of $3.50 per copy, or such other price as may be hereafter fixed by the board of directors. Certain easy requirements must be met and these privileges cannot be had by anyone for more than three years. Students are not limited to technical schools, but include those pursuing electrical studies in the correspondence schools or privately. In connection with this idea a number of local or branch meetings of the Institute have been established at fourteen of the leading technical schools.

The Fresno City Railway Company, of Fresno, Cal., has recently placed in service a 20-ton electric locomotive car for the purpose of hauling freight cars, and also carrying freight and supplies. This line is an outlet for a heavy shipping district and transfers a great deal of freight to the steam roads. The locomotive is driven by four motors of 50-h.p. each, one upon each axle, and is equipped with standard automatic couplers. The car was furnished by the J. G. Brill Company, Philadelphia, Pa., the trucks used being the improved Brill No. 27 high-speed type.

AN ARGUMENT FOR BLUE LEAD.

By a slip which cannot be blamed upon compositor, printer or office boy, under the heading "Blue Lead as a Pigment for Paint," on page 198 of our May number, an error occurred in the first line, which should read, "An argument in favor of blue lead as a pigment."

EQUIPMENT AND MANUFACTURING NOTES.

The Lunkenheimer Company, Cincinnati, report that on account of the unprecedented demand for their brass and iron steam specialties they have been compelled to increase their foundry output 50 per cent. Machine tools of the most improved types are being installed in various departments as fast as they can be obtained.

The Columbus Steel Rolling Shutter Company, Columbus, Ohio, inform us that they have appointed the F. P. Smith Wire and Iron Works, 100-102 Lake street, Chicago, manufacturers of ornamental and structural iron, art brass and wirework, sole agents in Chicago and several other States adjacent thereto for the sale of the Columbus rolling steel doors for freight houses, shop buildings, car-barns, warehouses, etc., owing to the large number of orders coming in from the West.

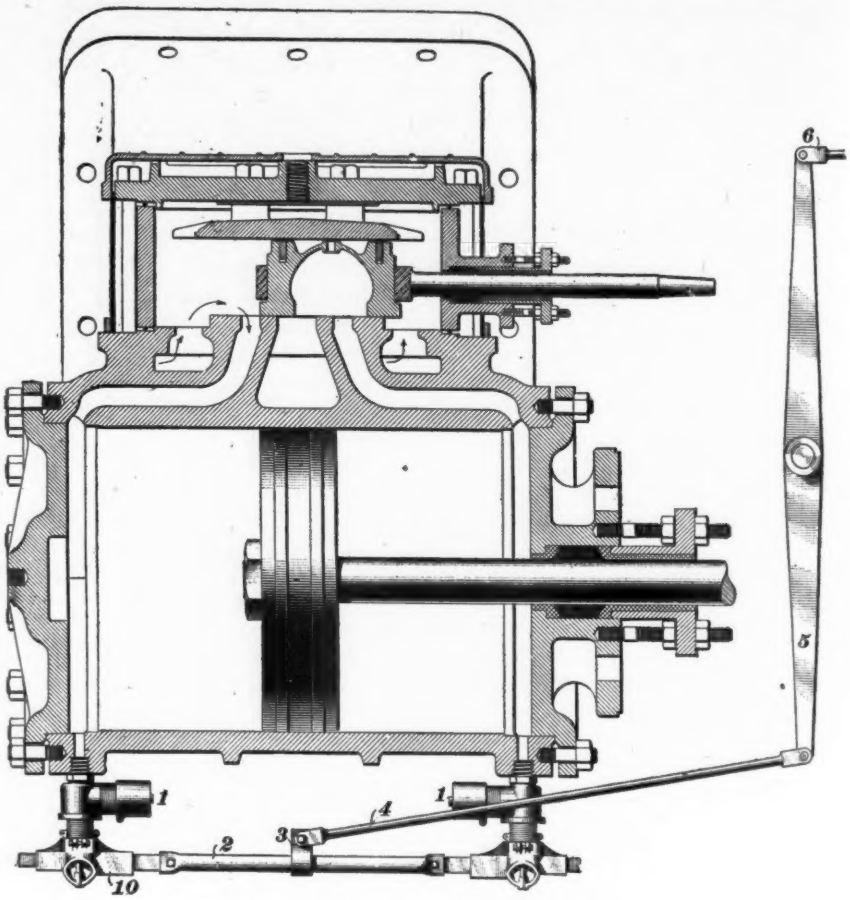
Mr. W. O. Duntley, of the Chicago Pneumatic Tool Company, has just returned from a short business trip abroad in the interests of his company. While on the Continent he visited several of the most prominent shipyards and manufacturing establishments and brought back with him a large number of orders for the various pneumatic appliances manufactured by his company. Mr. Duntley expresses himself as somewhat astonished at the readiness with which European industries adopt American labor-saving machinery, and in speaking of his trip says: "American labor-saving machinery is indeed becoming firmly established in the old countries. Particularly is this true of pneumatic appliances, and in the large majority of the shops, and especially in the prominent shipyards which I visited. 'Boyer' and 'Little Giant' pneumatic tools were in continuous service and giving excellent satisfaction. The large English and German ship owners have adopted pneumatic tools almost exclusively, and although occasionally an instance will be found where the old hand methods still prevail, they are certainly the exception rather than the rule, as was the case but a few years ago. Our foreign plants are taxed to their utmost capacity to adequately fulfill requirements, and in all probability extensive improvements will be necessitated in order to take proper care of the immense influx of business. In fact, the outlook for pneumatic tool business on the Continent is most promising indeed and all indications point toward a record-breaking year in the pneumatic tool industry, both for foreign and domestic business."

Mr. A. Rieppel, Koeniglicher Baurat, of Nurnberg, Germany, the managing director of the Augsburg Nurnberg Manufacturing Company, well known for many years as one of the largest and most successful builders of structural iron work, engines, cars, bridges, etc., in Europe, is now visiting this country. His works employ about 16,000 men and now have over 2,000 at work on the bridges of the new railroads being built by Germany in China. Their latest success has been with gas engines, both for gaseous and liquid fuel. They have long built these engines in smaller units up to 400 h.p. and operated with petroleum, but for the use of waste gas as well as producer gases and in larger units, they have recently developed an entirely new design constituting the result of many years of extensive experience. The engine, which is of the double-acting type, generally in tandem arrangement, is adapted for the various purposes of modern power development up to the largest units required by municipal central stations and iron and steel works. Mr. Rieppel's visit to this country was made to interest the Allis-Chalmers Company in the manufacture of the products of his company. A contract was entered into by the two companies giving the Allis-Chalmers Company the exclusive right to manufacture and sell the Nurnberg gas engine for this country and selling rights in many foreign countries, especially the Far East and South Africa. The Augsburg Nurnberg Manufacturing Company, under the direction of Mr. Rieppel, has made a phenomenal success with this new gas engine, having within the past few months received orders for some 50,000 h.p. throughout Germany and Spain, chiefly for generating electric energy and for blast furnace and spinning mill work. One of these engines now being built is for an important spinning mill in northern Germany where the engine will be operated by producer gas. Mr. Rieppel is now on a tour of inspection throughout this country, after which he will visit the new and extensive works of the Allis-Chalmers Company at West Allis, where these engines will be built.

ZEHNDER AUTOMATIC RELIEF VALVE.

The accompanying illustrations show the Zehnder patent locomotive automatic vacuum compression and excess pressure relief valve, with cylinder cock attachments and auxiliary oiling device. By the use of this valve the vacuum and compression in the cylinders can be adjusted to and maintained at any desired amount, thereby increasing the power of the engine, reducing the coal consumption and causing the engine to ride more easily.

Fig. 1 is a sectional view of the valve, and Fig. 2 shows a sectional view of the cylinder of a simple locomotive with the cylinder automatic relief valves attached, showing connections by which the valves are governed from the cab. Referring to Fig. 1 valve 6 acts as a compression and vacuum relief and cylinder drain cock. It works automatically, except when held open or shut by the engineer through the medium of the cylinder cock levers as shown in Fig. 2. The normal position of this valve is open, being held by the spring 7, the tension of which is adjusted by the cap nut 9, to give the desired compression in the cylinder. When steam is admitted into the cylinder it closes valve 6 and holds it closed until the exhaust opens and reduces the pressure below the tension of spring 7, the valve then opens and remains so until the compression becomes sufficient to close it. The amount of compression therefore depends upon how late in the stroke valve 6 closes, being reduced by a late closure and increased by an early closure. The tension of spring 7 should be adjusted to give just sufficient compression to properly cushion the piston. In drifting, valve 6 opens and relieves the vacuum that otherwise would be formed. Valve 3 prevents excessive pressure in the cylinder, the spring 4 being adjusted to resist a pressure slightly above boiler pressure. The auxiliary attachment, 12, is provided for lubricating cylinders in the event of the failure of the regular lubricating devices or a break-down necessitating the blocking of the steam valve, but permitting the main rod being left up. These valves are now being put on the market by C. F. Beckwith & Co., of Scranton, Penn., as general agents for the Zehnder valves. Detailed information will be furnished on application.



ZEHNDER AUTOMATIC RELIEF VALVE.

FIG. 2—SECTIONAL VIEW OF CYLINDER.

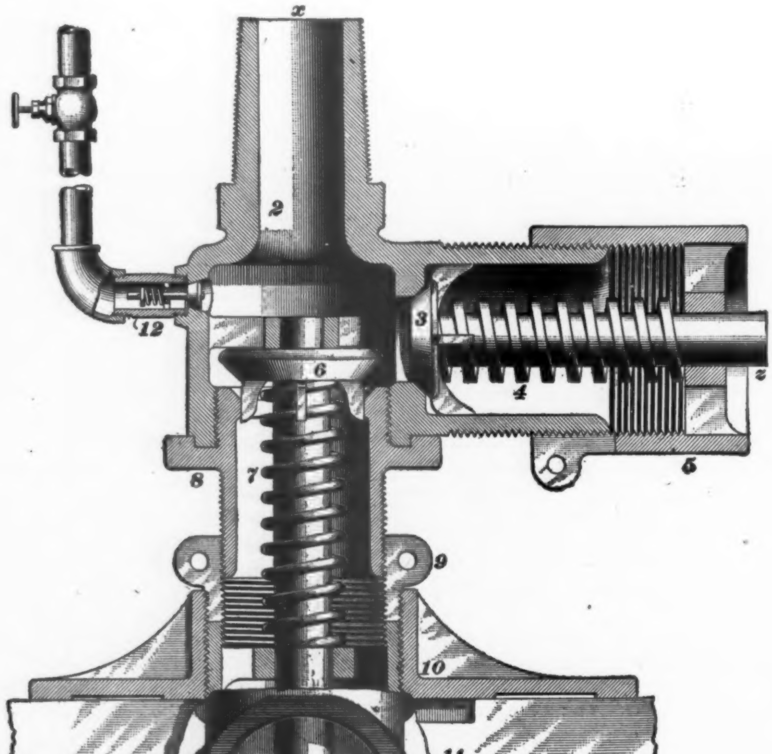


FIG. 1.

A high-speed run was recently made upon the Aurora, Elgin & Chicago third-rail electric railway which is said to be a record-breaker for electric railroad practice. A single-motor car made a special run, under regular traffic conditions, from the Chicago terminal at Fifty-second avenue to Aurora—a distance of 35 miles—in 34½ minutes. During a spurt 5 miles of the run were made in 4 minutes and 5 seconds, a rate of speed corresponding to 73½ miles per hour. This is claimed to break the record for constant running for long distances upon electric railways.

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A TABULAR COMPARISON OF NOTAB

ARRANGED WITH RES

PASSENG

Type—Drivers	4-6-0	4-4-2	4-4-0	4-4-2	4-6-0	4-4-2	4-6-2	2-6-2	4-4-2	4-4-2
Type—Name	10-wheel	Atlantic	Chautauqua Atlantic	Atlantic	10-wheel	Chautauqua Atlantic	Pacific	Prairie	Atlantic	Atlantic
Name of railroad	Plant System	C. & N. W.	C., R. I. & P	C. R. R. of N. J.	L.S. & M.S.	B. R. & P.	Mo. Pac.	L.S. & M.S.	N. Y. C. & H. R.	Pa. Lines
Number of road or class	119	D	1301	....	I-1	162	1118	J	I-2,980	E2A
Builder	Baldwin	Schenectady	Brooks	Baldwin	Brooks	American	American	Brooks	Sch'n't'dy	American
Simple or compound	4-cyl. bal. Compound	Simple	Simple	Vauclain Compound	Simple	Simple	Simple	Simple	Simple	Simple
When built	1902	1900	1901	1899	1899	1902	1902	1901	1901	1903
Weight, engine total, lbs	155,000	158,000	162,000	163,510	171,800	173,000	170,000	174,500	176,000	176,600
Weight, on drivers, lbs	114,000	91,000	87,000	87,865	133,000	99,000	118,000	130,000	94,800	109,000
Weight, on leading truck, lbs	41,000	33,000	38,000	41,295	38,800	40,000	35,500	21,500	42,600	36,600
Weight, on trailing truck, lbs	....	34,000	37,000	34,350	....	34,000	31,500	23,000	38,600	31,000
Weight of tender (loaded), lbs	....	(empty) 43,200	110,000	100,900	112,000	120,000	117,000	124,500	112,000	143,800
Wheel base, driving, ft. and ins.	14-1	7-0	7-0	7-3	16-6	8-0	12-4	14-0	7-0	7-5
Wheel base, total, engine, ft. & ins.	28-4	26-9	28-8	26-7	27-4	20-2	30-5	31-10	27-3	30-9½
Wheel base, total engine and tender, ft. and ins.	56-0	54-8¾	53-7	53-2	55-2¼	....	55-1½	57-3¼	53-0	60-2½
Driving wheels, diameter, ins.	73	80	78½	84¼	80	72	69	80	79	80
Cylinders, diameter, ins.	15 & 25	20	20¼	14 & 24	20	20¼	20	20½	21	20½
Cylinders, stroke, ins.	26	26	26	26	28	26	26	28	26	26
Heating surface, firebox, sq. ft.	128	170.7	189.00	136	223	202.3	153	169.3	180	165.7
Heating surface, arch tubes, sq. ft.	....	28.27	....	43	....	....	22	20.7	27.1	....
Heating surface, tubes, sq. ft.	2,665	2,816.91	2,617.00	2,478	2,694	2,805.6	2,778.5	3,172.0	3,298.1	2,474
Heating surface, total, sq. ft.	2,793	3,015.88	2,806.00	2,657	2,917	3,007.9	2,953.5	3,362.0	3,505.2	2,639
Firebox, length, ins.	131	102⅛	108	114	121	108	78	84⅛	96⅛	111
Firebox, width, ins.	59½	65¼	74	96	41	74	79¼	83¼	75⅜	72
Grate area, sq. ft.	27.25	46.27	54	76	36.6	54.4	42.4	48.6	50.3	55.5
Boiler, smallest diameter of, ins.	67	68⅜	66	64	66	70⅛	64	66.0	72	67
Boiler, height of center above rail, ft. and ins.	....	9-1½	9-7¼	9-0⅛	9-2	9-7½	9-6	9-2	9-3	9-1
Tubes, number & diameter in ins.	341-2	338-2	322-2	318-2	345-2	336-2	256-2¼	285-2¼	396-2	315-2
Tubes, length, ft. and ins.	15-0	16-0	15-7¾	15-0	15-0¼	16-0¼	18-6½	19-0	16-0	15-1
Steam pressure, lbs., per sq. in.	200	200	210	200	210	220	200	200	200	205
Type of boiler	Vanderbilt	Straight	Wagon top	Wootten	Extended Wagon-top	Straight	Rad. W. T.	Wagon top	Wide box	Belpaire
Fuel	Soft coal	Soft coal	Soft coal	Fine Ant.	Bitum. coal	Bitum. coal	Bitum. coal	Bitum. coal	Bitum. coal	bitum. Coal
Reference in American Engineer and Railroad Journal	Mar., 1902 P. 72	Aug., 1900 P. 237	Apr., 1901 P. 101	....	Nov., 1899 P. 343	Jan., 1902 P. 29	Aug., 1902 P. 236	Mar., 1901 P. 69	Feb., 1901 P. 35	April, 1903 P. 131
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FREIGH

Type—Drivers	2-8-0	4-8-0	2-8-0	2-8-0	2-8-0	2-8-0	2-8-0	2-8-0	2-8-0	4-8-0
Type—Name	Consol.	Mastodon	Consol.	Consol.	Consol.	Consol.	Consol.	Consol.	Consol.	Mastodon
Name of railroad	L. S. & M. S.	So. Pac.	N. Y. C.	P. R. R.	Nor. Pac.	N. Y. C.	C., R. I. & P.	A., T. & S. F.	I. C.	D., L. & W.
Number of road or class	B-1	2026	G-2	H-6-A	Y-2	2399	1603	836	639	808
Builder	Brooks	Schenectady	Schenectady	P. R. R.	American	American	American	American	Rogers	Brooks.
Simple or compound	Simple	2-cylinder Compound	2-cylinder Compound	Simple	Tandem Compound	Tandem Compound	Simple	Tandem Compound	Simple	Simple
When built	1900	1898	1901	1899	1901	1902	1903	1902	1899	1899
Weight, engine total, lbs	174,000	192,000	192,000	193,500	198,000	200,000	200,500	201,000	203,000	205,000
Weight, on drivers, lbs	154,000	155,000	166,000	173,900	175,000	172,500	180,000	176,000	184,800	166,000
Weight, on leading truck, lbs	20,000	37,000	26,000	20,500	23,000	27,500	20,500	25,000	18,200	39,000
Weight, on trailing truck, lbs	......	......	......	......	......	......	......	......	......	......
Weight of tender (loaded), lbs	124,500	empty 39,650	108,500	134,700	empty 47,000	108,000	144,500	empty 46.400	147.600	106,600
Wheel base, driving, ft. and ins.	17-4	15-6	19-0	16-6½	17-0	17-0	17-0	15-4	16-3	15-0
Wheel base, total, engine, ft. & ins.	25-6	26-5	25-11	24-9	26-2	26-3	26-0	24-1	24-5	25-9
Wheel base, total engine and tender, ft. and ins.	55-4¼	53-6½	53-10	58-1½	53-10½	54-3	57-6	......	56-10½	50-4¼
Driving wheels, diameter, ins.	62	55	63	56	65	63	63	57	57	54
Cylinders, diameter, ins.	21	23 & 35	23 & 35	22	15 & 28	15 & 28	22	18 & 28	23	21
Cylinders, stroke, ins.	30	32	34	28	34	34	30	32	30	32
Heating surface, firebox, sq. ft.	199	206.5	155.4	166.5	155.64	155.4	177	178	221	218
Heating surface, arch tubes, sq. ft.	22.3	......	27.1	......	26.43	27.09	......	......	......	......
Heating surface, tubes, sq. ft.	2,653.0	2,819.3	3,298.08	2,675.9	3,231.9	3,298.08	3,087	2,787	2,982	2,950
Heating surface, total, sq. ft.	2,874.3	3,025.8	3,480.6	2,842.4	3,414.0	3,480.57	3,264	2,965	3,203	3,168
Firebox, length, ins.	120¼	120	96	107	100 1-16	96	108	101⅛	132	123
Firebox, width, ins.	40¼	42	75⅜	66	75¼	75	68	71¼	42	97
Grate area, sq. ft.	33.5	35	50.32	49.1	52.3	50.32	50	50	38.5	82.4
Boiler, smallest diameter of, ins	68⅜	72	70⅝	69.5	66.5	70⅝	72	68	79¾	83⅞
Boiler, height of center above rail, ft. and ins.	9-4⅛	......	9-7	9-2	9-5	9-7	9-9	......	9-2	9-2½
Tubes, number & diameter in ins.	340-2	332-2¼	396-2	373-2	388-2	396-2	383-2	355-2	417-2	410-2
Tubes, length, ft. and ins.	15-0⅛	14-6	16-0	13-8½	16-0	16-0	15-6	15-0	13-8	13-10¼
Steam pressure, lbs., per sq. in.	200	200	210	205	210	210	200	210	210	200
Type of boiler	Wagon top	Extended Wagon top	Wide box	Belpaire	Wide box	Straight	Wagon top	Wagon top	Belpaire	Wide box
Fuel	Bitum. Coal	Bitum. coal	Bitum. coal	Bitum. Coal	bitum. Coal	Bitum. Coal	Bitum. coal	Bitum. coal	Bitum. Coal	Ant. coal
Reference in American Engineer and Railroad Journal	Feb., 1900 P. 37	Jan., 1899 P. 26	March, 1901 P. 83	June, 1899 P. 177	Sept., 1901 P. 271	April, 1903 P. 127	March, 1903 P. 107	June, 1902 P. 179	Jan., 1900 P. 13	Nov., 1899 P. 365
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NOTE—These figures have been verified by the railroad officials in charge.

EXAMPLES OF RECENT LOCOMOTIVES.

TOTAL WEIGHTS.

OTIVES.

4-4-2	2-8-0	4-4-0	4-4-2	2-6-2	4-6-2	4-4-2	4-6-0	4-6-2	2-6-2	2-6-2	Special	4-6-2
Atlantic	Consol.	Atlantic	Atlantic	Suburban	Pacific	Chautauq'a Atlantic	10-wheel	Pacific	Prairie	Prairie	Suburban	Pacific
C., M. & St. P.	Col. Mid.	C., B. & Q.	A., T. & S. F.	C. R. R. of of N. J.	C. & O.	C. R. R. of of N. J.	L. V.	Nor. Pac.	I. C.	A., T. & S. F.	N. Y. C.	C. & A.
A-2	201	1586	......	200	147	590	10D-17W	284	1000	P-14-A	1410	601
Baldwin Vauclain	Baldwin Vauclain	Baldwin Vauclain	Baldwin Balanced	Baldwin	American	American	Baldwin Vauclain	American	Rogers	Baldwin Vauclain	American	Baldwin
Compound	Compound	Compound	Compound	Simple	Simple	Simple	Compound	Simple	Simple	Compound	Simple	Simple
1901	1901	1902	1903	1902	1902	1901	1900	1903	1902	1901	1902	1903
181,535	181,700	183,080	187,000	189,900	190,000	191,000	194,758	202,000	210,800	210,800	216,000	219,000
100,335	158,500	95,880	90,000	129,000	131,000	99,400	141,348	134,000	140,200	143,600	128,000	141,700
45,100	23,200	47,000	52,000	21,900	32,000	48,000	53,410	39,000	21,200	29,700	......	36,300
36,100	......	40,200	45,000	39,000	26,000	43,600	....	29,000	40,400	37,500	......	41,500
120,000	126,900	......	140,000	Side tank	123,400	124,000	96,500	123,400	147,600	112,600	......	155,000
7-3	15-9	7-3	6-4	14-0	12-8	7-8	13-0	12-0	13-6	13-8	15-0	13-9
27-11½	24-4	27-8	15-0	31-8	32-8	29-10	25-3½	33-0	30-9	32-2	35-9	32-8
57-5½	53-2	56-0	58-3½	31-8	60-0	53-8	52-6⅞	58-4½	62-1½	57-8¾	35-9	62-0
84	60	84¼	73	63	72	85	72	69	75	79	63	80
15 & 25	17 & 28	15 & 25	15 & 25	18	22	20½	17 & 28	22	20	17 & 28	20	22
28	30	26	26	26	28	26	26	26	28	28	24	28
207	172.2	155.5	190	96.6	182	174	171.71	175.3	201	195	162	202
......	......	......	......	43.0	23	......	......	22.9	......	......	......	28
3,008	2,453.7	2,834.5	2,839	1,695.0	3,328.3	2,793.0	2,536.59	3,265.1	3,333	3,543	2,275	3,848.0
3,215	2,625.9	2,990.0	3,029	1,834.6	3,533.3	2,967.0	2,708.3	3,463.3	3,534	3,738	2,437	4,078.0
102	120⅛	96⅛	117 15-16	109	90	123	114	90 3-16	102	108	93	108
65⅞	42	66⅞	66	72	75	97	89⅞	75⅜	72	71¼	97⅞	72
46.76	35	44.25	49.4	54.5	47	82	71.25	47.2	51	53.5	62.1	54
66	74	64	66	60	66	68	64	70	68	70	70	70
9-5½	......	......	8-9	9-0	9-0	9-8½	9-2	9-2½	9-2	9-4	9-2 1-16	9-5
350-2	337-2	330-2	273-2¼	249-2	291-2¼	325-2	325-2	301-2¼	335-2	318-2¼	365-2	328-2¼
16-6	14-0	16-6	18-1	13-0	19-6	16-6¼	15-0	18-6	19-0	19-0	12-0	20-0
200	200	210	220	200	200	210	200	200	200	200	200	220
Wagon top	Straight	Extended Wagon top	Wagon top	Straight	Wagon top	Wagon top	Wide box	Straight	Wagon top	Straight	Straight	Straight
Bitum. coal	Bitum. Coal	Bitum. coal	Bitum. Coal	Ant. coal	Bitum. Coal	Ant. coal	Ant. coal	Bitum. Coal	Bitum. coal	Bitum. coal	Ant. coal	Bitum. Coal
Oct., 1901	Feb., 1902	April, 1902	June, 1903	June,1902	Sept., 1902	Jan., 1902	Oct., 1900	Feb., 1903	June, 1902	Dec., 1901	April, 1902	Mar.,1903
P. 313	P. 49	P. 119	P. 210	P. 200	P. 283	P. 15	P. 312	P. 63	P. 199	P. 373	P. 115	P. 87
18 - Jan 10 '02		– – – –	------	June 27		Jan 2		Feb 27	June 6		June 27	Feb 20

OTIVES.

2-8-0	2-10-0	4-8-0	2-8-0	4-8-0	2-8-0	2-8-0	2-8-0	2-8-0	2-10-0	2-8-2	2-10-0	0-10-0
Consol.	Decapod	Mastodon	Consol.	Mastodon	Consol.	Consol.	Consol.	Consol.	Decapod	Mikado	Decapod	Geared
Nor. Pac.	Soo	Gt. N.	A. T.& S. F.	Ill. Cent.	L. V.	N. Y. C.	Union	B. & L. E.	A., T. & S. F.	A. T. & S. F.	A. T. & S. F.	Rock Isl-and
Y-3	600	100	824	640	....	G 4	95	150	989	900	940	165
American	Baldwin Vauclain	Brooks	Baldwin Vauclain	Brooks	Baldwin Vauclain	American	Pittsburgh	Pittsburgh	American	Baldwin Vauclain	Baldwin	Lima
Tandem Compound	Comp.	Simple	Comp.	Simple	Compound	Tandem C	Simple	Simple	Tandem C	Compound	Tandem Compound	Simple
1901	1900	1898	1902	1899	1898	1903	1898	1900	1902	1902	1902	1902
209,500	210,000	212,750	214,600	221,450	225,082	227,000	230,000	250,300	259,800	261,720	267,800	291,000
185,500	185,100	172,000	191,400	181,400	202,232	201,000	208,000	225,200	232,000	199,670	237,800	291,000
24,000	24,900	40,750	23,200	40,050	22,850	26,000	22,000	25,100	27,800	27,250	30,000	....
......	....	....	....	....	....	....	....	....	....	34,800	....	....
empty 47,000	124,550	96,900	110,000	147,600	121,000	133,850	104,000	141,100	134,900	162,000	....	(empty) 62,500
15-0	19-4	15-10	15-4	15-9	15-0	15-0	15-7	15-7	20-0	16-0	20-4	44-5
23-8	28-0	26-8	24-6	26-6	23-10	23-7	24-0	24-4	28-11	31-6½	29-10	44-5
52-4½	58-3	53-11	54-2¾	60-2½	55-0½	59-1	54-9½	57-11¾	62-0	62-0	59-6	54-4
55	55	55	57	57	55	51	54	54	57	57	57	40
15 & 28	17 & 28	21	17 & 28	23	18 & 30	16 & 30	23	24	17½ & 30	18 & 30	19 & 32	15
34	32	34	32	30	30	30	32	32	32	32	32	17
173	201	235	165	263	215	201	205	241	205.4	210.3	210.3	156
22.9	....	....	....	....	....	26	....	....	....	....	23.9	....
3,450.4	2,799	2,730	4,031	3,237	3,890.6	3,915	3,116.5	3,564	4,476.5	5,155.8	5,155.8	1,837
3,646.3	3,000	2,965	4,266	3,500	4,105.6	4,142	3,321.5	3,805	4,681.9	5,366.1	5,390	1,993
100 1-16	132	123	84	132	120	105	120	132	108 1-16	108	108	96
75¼	41	39¾	3-28 dia.	41¼	108	79	40.5	40.25	79¼	78	78	54
52.3	37.5	34	....	37.5	90	58	33.5	36.8	59.5	58.5	58.5	36
74¾	68	78	74	80⅛	80	77	80	84	78¾	78¾	78.75	60
9-3¼	8-11	9-5	9-2	9-8	8-7⅜	9-3	9-3⅜	9-11¾	....	9-10	....	....
442-2	344-2	376-2¼	652-1¾	424-2	511-2	507-2	355-2¼	406-2¼	413-2¼	463-2¼	463-2¼	270-2
15-0	15-7	13-10⅝	13-7	14-8⅜	14-7¾	14-9	15-0	15-0	18-6	19-0	19-0	13
210	215	210	210	210	200	210	200	220	225	225	225	190
Wide box	Extended Wagon top	Belpaire	Extended Wagon top	Belpaire	Wootten	Extended Wagon top	Straight	Straight	Extended Wagon top	Wagon top	Wagon top	Wagon top
Bitum. coal	Bitum. Coal	Bitum. coal	Oil	Bitum. Coal	Ant. coal	Bitum. coal	Bitum. coal	Bitum. coal	Oil	Bitum. coal	Bitum. Coal	Soft coal
......	Oct., 1900	Jan., 1898	Jan., 1902	Oct., 1899	Dec., 1898	May, 1903	Nov., 1898	July, 1900	Feb., 1902	Jan., 1903	June, 1902	Aug., 1902
......	P. 319	P. 1.	P. 10	P. 315	P. 395	P. 174	P. 365	P. 214	P. 38	P. 16 and Mar., 1903, P. 109	P. 192	P. 244
			-----			May 15			Feb 31		May 30	